Governing embodied emissions:
informational institutions and the evolution towards consumption-based approaches in climate policy

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**Declaration**

I, Nino David Jordan, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.
Abstract

The failure to include greenhouse gas emissions embodied in trade is one of the biggest stumbling blocks on the road to more effective global climate governance. The thesis traces how the combined informational effects of a diverse set of environmental policies and initiatives have enabled the emergence of institutions facilitating the production of reasoned estimates on the carbon embodied in products and services. The availability of information on the emissions embodied in products allows novel actor coalitions to emerge and advocate for a variety of different policies utilising such information in order to reduce greenhouse gas emissions. The thesis analyses how differences in policy design lead to variation in business support. Embodied emissions policies can be seen as a way of imposing decentralised graduated sanctions on non-cooperative actors which promises to profoundly improve the prospects of polycentric climate governance. The thesis provides an original contribution to scholarship on global environmental governance and environmental policy by analysing the institutional and political dynamics of the emerging ensemble of institutions that provide the informational basis for governing the greenhouse gas emissions embodied in trade. It demonstrates that complex informational and political effects need to be taken into consideration in the valuation of individual policies. It concludes with concrete policy advice for decision-makers.
Impact statement

Climate change is among the major global problems of the 21st century. Existing approaches towards climate change mitigation suffer from competitiveness issues that arise when carbon constraints are only enforced in one place but not another, where these are connected via trade. Better information about the carbon emissions associated with the production and distribution of goods could help policy-makers to target those ‘embodied’ emissions in principled and non-discriminatory ways compatible with a liberal trade regime. Doing so would greatly improve the prospects of effective decentralised climate governance in a world in which important actors are not willing to cooperate on this issue. This study examines which developments have brought about more demand for such information on embodied emissions, its sources, how they are made comparable, and the political implications of such data availability. The study highlights how the availability of standardised methods for assessing the embodied carbon of products can lead to the emergence of novel coalitions demanding embodied emissions policies, i.e. political support for actions addressing the emissions embodied in trade. This study’s insights on the complex, often transnational, interplay between various environmental initiatives and policies can help to better align the actions of activists, policy-makers, researchers and businesses in the pursuit of more effective global climate governance.
To my parents
Barbara Jordan and Dan Nielsen
roots, environmentalists, too
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Declarations of interest

The author’s academic affiliation, the UCL Institute for Sustainable Resources (ISR), is a member of the Association for Sustainable Building Products (ASBP). The ASBP is subject to analysis here. The author only became aware of the affiliation between UCL ISR and ASBP late in the research process and has not had any external incentives to portray the ASBP in a particularly negative or positive light.
List of Abbreviations

ASBP  Association for Sustainable Building Products

BAT  Best available technique / Best available technology

BCA  Border Carbon Adjustments

BDI  Bundesverband der Deutschen Industrie (Federal Association of the German Industry)

BNB  Bewertungssystem Nachhaltiges Bauen (Evaluation System for Sustainable Construction)

BRE  Building Research Establishment

BREF  Best available technique reference

BREEAM  BRE Environmental Assessment Method

CAA  Clean Air Act

CalCIMA  California Construction and Industrial Materials Association

CDP  formerly Carbon Disclosure Project

CEN  European Committee for Standardisation

CCA  Climate Change Agreement

CSH  Code for Sustainable Homes

CSI  Cement Sustainability Initiative

CSR  Corporate Social Responsibility

DENEFF  Deutsche Unternehmensinitiative Energieeffizienz (German Business Initiative for Energy Efficiency)
List of Abbreviations

DGNB Deutsche Gesellschaft für Nachhaltiges Bauen (German Sustainable Building Council)

DHWR Deutscher Holzwirtschaftsrat (German Wood Business Council)

DoE United States Department of Energy

EAP Environmental Action Programme

EIO Environmental input-output

EMS Environmental Management System

EnEv Energy Saving Ordinance (Energieeinsparverordnung)

EPA United States Environmental Protection Agency

EPD Environmental Product Declaration

E-PRTR European Pollutant Release and Transfer Register

EU ETS European Union Emissions Trading System

GHG Greenhouse Gases

GNR Getting the Numbers Right

GRI Global Reporting Initiative

GWP Global Warming Potential

IBU Institut Bauen und Umwelt

IGT Innovation and Growth Team

IPC Integrated pollution control

IPCC Intergovernmental Panel on Climate Change

IPPC Integrated Pollution Prevention and Control

ISO International Organization for Standardization

LCA Life Cycle Assessment / Life Cycle Analysis

LCI Life cycle inventories
LEED  Leadership in Energy and Environmental Design

KfW  Kreditanstalt für Wiederaufbau (German Development Bank)

MPA  Mineral Products Association

MRV  Monitoring, Reporting and Verification

NABU  Naturschutzbund Deutschland (German Nature and Biodiversity Conservation Union)

NDCs  Nationally Determined Contributions

OEF  Organisation Environmental Footprint

PCA  Portland Cement Association

PCF  Product Carbon Footprint

PCR  Product Category Rule

PEF  Product Environmental Footprint

RICS  Royal Institution of Chartered Surveyors

TRI  Toxic Release Inventory

UNEP  United Nations Environment Programme

UNEP SBCI  UNEP Sustainable Buildings and Climate Initiative

UNFCCC  United Nations Framework Convention on Climate Change

USGBC  US Green Building Council

VDZ  Verein Deutscher Zementwerke (German Association of Cement Plants)

WBCSD  World Business Council for Sustainable Development

WRI  World Resource Institute
1. Introduction

In the fight against climate change even the most ambitious countries hold back from radically decarbonising their economies. They fear that bold but costly action would undermine their economic competitiveness. Even the environmental gains might be diminished, as the liberal trade regime would permit cheap carbon-heavy imports to outcompete carbon-light domestic produce. Opting out of the liberal trade regime could lead to economic disruption, and fail to inspire others to follow suit.

A global climate deal was supposed to solve this conundrum. Instead of solving it, the Paris Agreement seeks to slowly build up ambition, letting it grow organically and reciprocally. Yet slow does not mean steady: it is a fragile ambition, and prone to disruption. It is an ambition nourished by morals and the desire for good reputation but steadily undermined by economic calculus.

An important alternative to a global treaty with enforceable emission reductions obligations consists in the establishment of decentralised and graduated sanctioning mechanisms which could be directed against those who do not wish to sufficiently cooperate on the prevention of excessive global heating. If carbon-heavy goods, regardless of their origin, were burdened with a carbon price, low-carbon goods would become more competitive. If such a price extended to goods from countries not sufficiently cooperating on climate change, even producers in those countries would develop an interest in reducing their carbon intensity.

But how could one determine a fair carbon price for products from abroad? How could one find an agreeable price without descending into a spiral of accusations of protectionisms and the break-down of trade arrangements? One would need to know about the greenhouse gas emissions associated with the various stages of a good’s production and transportation.

Metrics such as ‘carbon’ or ‘global warming potential’ have emerged as the units of account making otherwise different acts and qualities commensurable. The past decades have seen an ever increasing amount of information on the carbon emissions associated with diverse activities such as transport, industrial
1. Introduction

production, energy generation, and agriculture. As more and more such information becomes available, the data basis for calculating the emissions ‘embodied’ in products improves.

This information, however, does not simply accumulate over time. It needs to be brought about by stimulating both supply and demand. In order to know how to generalise and accelerate this process, as a first step it is important to ask: what institutional developments have contributed to the availability of such information?

One could adopt the perspective of an advisor to an imaginary policy-maker who can decide for a country, or perhaps the world, unhindered by political considerations. Instead, I ask: what can the many, very real, decision-makers with limited power and influence do to enable the attribution of ‘embodied’ emissions to products?

Scholars, policy-makers and activists alone are not likely to establish mechanisms for effectively addressing emissions embodied in trade, unless they manage to cultivate and nourish coalitions, in particular ‘winning coalitions’, which can mobilise a diverse set of actors, with otherwise different interests, to rally behind advocacy for climate change policies (Levin et al. 2012, 140). Would the availability of information on the emissions embodied in products make a difference to climate politics? Does it affect the way actors organise politically?

This thesis provides a novel contribution to the field of environmental studies: it comprehensively analyses how different policies and initiatives have improved the informational conditions for the attribution of embodied emissions. It shows how differences in the design of embodied emissions policies affect the division between those who advocate for and resist against these policies. And it considers how embodied emissions policies could help to substantially improve the possibilities for effective polycentric climate governance.

Figure 1.1 provides an overview of the thesis argument, detailing which chapters comprise which lines of argumentation: different environmental policy regulations stimulate both the generation of information on the environmental impacts of production as well as demand for information on the embodied environmental impacts of products. The availability of information on the environmental impacts of production provides an important basis for the assessment of the embodied environmental impacts of products. The availability of information on the embodied environmental impacts of products enables both the introduction of policies targeting embodied emissions as well as, correspondingly,
new framings for the articulation of political demands. In the face of both the redistributive effects associated with embodied emissions policies as well as the availability of new framings, existing political lobby coalitions re-align and a group emerges that engages in advocacy for policies targeting embodied emissions. These policies, in turn, have the potential to raise the level of ambition of other climate policy regulations, which themselves do not target embodied emissions. Embodied emissions policies can also be interpreted as a form of decentralised sanctions, which improve the chances of arriving at a successful polycentric management of the atmosphere as a form of common property.

Policies that help to create, elicit, standardise, legitimise and circulate information can help to build capacity for other policies that rely on such information. In this sense, a policy intervention at time $t$ can affect the policy content of a political situation at time $t + 1$. When such effects, over time, affect the original policy, we can talk about policy feedback (Jordan and Matt 2014, 231).

Policies can also have informational feed-forward effects (Jordan and Matt 2014, 231) across sectoral and geographical boundaries: a policy $1$ at a geographical place $p_1$ and a production chain stage $s_1$ may induce information-production that can be conducive to a policy $2$ at a geographical place $p_2$ and a production chain stage $s_2$.

Actors at different stages of value chains may have different interests and such business conflict can be exploited by those who seek to advance environmental reform (Falkner 2008, 16–48). The availability of information structures the feasibility of different types of policy (Esty 2004; Mol 2008). By helping to transmit environmental information through value chains, the emerging polycentric institutional ensemble governing the representation of embodied emissions has the potential to open up new possibilities for regulation further down the value chain, and thereby shift the locus of political contestation. As a result, novel coalitions of actors unite behind demands for policies targeting the emissions embodied in products. Such policies, in turn, have the potential to provide incentives for a radical lowering of the carbon intensity of production and thereby to exert effects onto the original conditions for the adoption of carbon emissions related policies.

The next chapter works out the relevance of information on embodied emissions in the context of the deficits of the current climate change governance landscape. The chapter identifies the lack of decentralised graduated sanctioning mechanisms as a major gap in the governance landscape and shows how this
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Figure 1.1.: Overview of thesis argument
severely inhibits carbon pricing efforts as one of the main policy instruments for tackling global heating. This has knock-on effects affecting other major strategies, such as the transition to renewable energy. Eminent economists have pointed towards the non-inclusion of consumption into climate policy as a major deficiency of carbon pricing schemes. Therefore, improved information on embodied emissions could significantly contribute towards more effective global climate change governance.

Policies and initiatives at various levels and in different jurisdictions, by state and non-state actors alike, can help to prepare the ground for more effective polycentric climate governance: the proliferation and standardisation of product carbon footprints (PCFs) in the form of Environmental Product Declarations (EPDs) help to facilitate a potential future inclusion of embodied emission into carbon pricing policies, and thus may help to prepare the ground for closing the consumption loophole in carbon pricing schemes.

If we accept that information on embodied emissions has the potential to contribute towards more effective polycentric climate change governance, those factors that drive demand and supply of information on embodied emissions appear as antecedent conditions for such a potential to realise. Consequently, evaluations of those policies and initiatives that form part of these antecedent conditions should take this potential into account. Once it is plausible that a greater availability of relatively reliable information on the emissions embodied in products has the potential to contribute towards greater climate governance effectiveness, it makes sense to claim that initiatives and policies contributing to such information supply have catalytic qualities in the sense that their presence helps to bring further change about.

Institutions that render the carbon emissions associated with economic processes visible, may help to mobilise novel alliances in favour of more ambitious carbon emissions reduction. My central hypothesis is that there is a step-wise progression from information production to the political mobilisation of actors for more ambitious action on global heating: information on carbon emissions serves as the raw material for commensuration processes to succeed, and commensurability enables new policies, with modified political opportunity structures, which allow novel coalitions to identify themselves as such and mobilise in the name of climate change mitigation and for a common cause.

In Chapter 3 I develop an institutionalist framework that helps to formulate propositions on how processes of institutional change have affected the sup-
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Supply and demand for information on embodied emissions, as well as the politics surrounding it. First, it helps to conceptualise how the supply of dispersed information on the environmental impacts of production can enable new policies targeting the emissions embodied in products. Second, it helps to establish the links between energy policy and the demand for information on embodied emissions. Third, it suggests mechanisms by which an increase in information supply, mediated via improvements in the technical feasibility of embodied emissions policies, can lead to the emergence of novel actor coalitions advocating for embodied emissions policies.

Based on the considerations in the theory chapter I develop more refined and concrete research questions and advance the following core propositions as the empirical basis for a holistic, synthesising analysis:

- **Information on product life cycle emissions facilitates relatively low carbon businesses to re-aggregate behind the low embodied emissions framing** (see Chapter 5)

- **Energy efficiency policy has indirectly helped to improve the informational basis for addressing emissions embodied in building materials** (see Chapter 6)

- **The availability of standardised quality information on embodied emissions is an important criterion for the legitimacy of policies addressing embodied emissions** (see Chapter 7)

- **A political environment that incentivises an intra-sectoral exchange on the environmental impacts of production will be conducive to the creation of sectoral life cycle data sets** (see Chapter 8)

- **Production-based environmental monitoring and reporting has spillover effects and thus drives down various costs for eventual product level disclosure of life cycle impacts** (see Chapter 9)

- **Energy efficiency and/or carbon policy indirectly help to generate higher quality carbon footprint data as they stimulate the diffusion of better energy metering equipment** (see Chapter 10)

- **Production-based monitoring and reporting has significantly contributed towards the availability of data on embodied carbon in background databases** (see Chapter 11)
Altogether, these empirical chapters demonstrate how environmental policy regulations change the informational environment for corporate actors with regard to their products and processes. Over time, this drives a shift from a pure focus on measuring production-based emissions to also measure embodied emissions. On the one hand, this shift can be observed in the sphere of corporate activity, where the increased capacity to deal with information on environmental impacts lays the ground for accounting for emissions embodied in products. On the other hand, the novel formatting of information on products in terms of embodied emissions enables actors to become realigned in the way they join in coalitions to lobby for their preferred climate policy outcomes.

The novel concerns of this thesis, and the ambition to provide a holistic and integral analysis, have called for a complementary mix of methods. The methodology chapter describes how the thesis evaluates the different propositions with a multi-method mix, consisting of process tracing, document analyses, qualitative and quantitative text analyses, network analysis, and interviews.

In Chapter 5 I examine how information availability affects coalition formation. The building and construction sector has so far seen the most notable emergence of such coalitions. Where policies targeting the emissions embodied in buildings become feasible, producers of different building materials, who would otherwise seek recognition or policy-support for their products in accordance with other categories such as ‘local’, ‘renewable’, ‘re-use’, ‘recycled’, or ‘natural’, may rally behind the common framing of ‘low embodied emissions’ and argue for policies taking those into account. I argue that the availability of the framing of ‘embodied emissions’ allows a diverse coalition of materials and service suppliers, who would otherwise frame the virtues of materials or practices in different ways, to unite behind similar demands. By extension, the antecedent conditions that help to provide the informational basis for making it plausible to rally behind the banner of ‘embodied emissions’ are also conditions that affect the formation of political interest groups.

This leads to the question: What have been the institutional preconditions conducive to the emergence of the demand for and supply of information on the emissions embodied in products?

In Chapter 6 I examine a major demand factor for information on embodied emissions: sustainable building certification schemes. I also look at actors that advocate for greater consideration of embodied emissions in public policy making. I argue that energy efficiency policies have helped to establish the ground
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for a greater consideration of embodied emissions and thus demand for information on them. Consequently, appraisals of energy efficiency policy should be extended by also taking into account the indirect effects of energy efficiency policies on the demand for information on embodied emissions, and the potential for a more effective climate change regime arising from it.

Chapter 7 describes the institutionalisation of the field of Life Cycle Assessment (LCA) and, in its wake, EPDs. It shows how important standards, data availability and quality are as part and parcel of contestation over the feasibility of policies targeting embodied emissions. It argues that the availability, quality and comparability of information is a key point of political contestation in disputes over the appropriateness of taking embodied emissions into account in policy-making. Consequently, the factors that drive supply and demand of information can be crucial to the emergence of political contestation about the inclusion of embodied emissions into policy-making, and to how these contests play out.

I denote the shift from place-based to placeless systems of disclosure and regulation, from point to flow, as rescoping. Regarding the supply of information on the environmental impacts embodied in products, I argue that institutions of place-based environmental monitoring and reporting have facilitated the emergence of systems that are not place-based but that seek to capture the environmental flows along the various production stages of a product. The four remaining empirical chapters examine a range of micro-mechanisms through which such rescoping – from place-based to place-less institutions of environmental monitoring and reporting – may work. They deal with different aspects of rescoping, differentiated according to the type of actor whose capacity to produce information on the environmental impacts embodied in products may have been enhanced by the presence of institutions of place-based environmental monitoring and reporting.

Chapter 8 on rescoping from the sectoral to the product level tests the proposition that a political environment that incentivises an intra-sectoral exchange on the environmental impacts of production will be conducive to the creation of sectoral life cycle data sets. I argue that actual or anticipated environmental policy has been an important driver for sectoral environmental transparency initiatives. Through this, state regulation has indirectly stimulated the private generation of information on the environmental impacts embodied in products.

I inquire into the prior initiatives and policies that have facilitated the avail-
ability of data for the production of EPDs within companies. Chapter 9 on
rescoping from the firm to the product level argues that policies and initiatives
targeted at improving the availability of information on the environmental im-
pacts of firm activity have been conducive to the availability of information on
the emissions embodied in products.

In Chapter 10 I argue that energy efficiency and/or carbon policy stimulate
the diffusion of better energy metering equipment and, thereby, help to improve
the conditions for generating higher quality carbon footprint data.

In Chapter 11 I look at the relationship between production-based disclosure
and the availability of background data that can provide the epistemic founda-
tions for embodied emissions assessments, where primary data is lacking. In
that chapter I argue that institutions of place-based environmental monitoring
and reporting have significantly increased the data available for the providers
of LCA background databases.

Whereas a lot of the information production on carbon flows and measurement
is privately organised (Jessica Green 2013a, 2013b; Green and Auld 2016), a trac-
king back of the conditions that facilitate the generation of knowledge about these
flows reveals that government policies and financial support have significantly
contributed to the availability of the information and standards that support
the assessment of the carbon emissions embodied in products. I inquire into the
prior policies that have facilitated the availability of data for the estimation of
generic life cycle data, which can be used even when specific company data is
absent: the identification of best available technologies (BATs) in environmental
policy-making as well as environmental disclosure policies such as toxic release
registers and emissions permits generate important information, which helps ex-
erts on environmental LCA to estimate the environmental impacts associated
with products. This is usually done via triangulation with other, less than per-
flect, data sources. This allows experts to come up with ‘conservative estimates’,
which can help to elicit more data from companies. By identifying these infor-
mational spillover effects, I point to a new aspect in the debate on the relative
advantages of standards versus market-based approaches in the domain of en-
vironmental regulation. More specifically, polycentrically distributed standards
have had informational externalities which have contributed to the emergence of
a public good in the form of greater overall knowledge on the approximate emis-
sions embodied in products. And greater information on embodied emissions
may eventually prop up market-based approaches.
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In addition, standards have also helped to, indirectly, prepare the informational basis for embodied emissions policies in other ways: energy efficiency standards have helped to raise the issue of embodied emissions in buildings and to increase their calculability. They have also promoted the diffusion of more precise energy measuring equipment in industry, which helps to create more accurate carbon footprints.

My results contribute to discussions on the relative merits of different policy types in relation to their informational characteristics. There is a tendency to argue that policy choice should be guided by the principle of informational economy, making those policies preferable that can do without much detailed knowledge of the domain that is to be regulated. I complement this position by arguing that a mere evaluation of policies with regard to their immediate informational economy neglects the important contribution that knowledge-intensive policies can make to the supply of information on the environmental impacts embodied in products.

It is important to be attentive to how such a supply of information can induce path-dependent political developments by increasing the technical feasibility of policies, re-arranging actor constellations and, eventually, opening new windows of opportunity for policy intervention. As a response to path-dependent socio-technical lock-ins (Unruh 2000) into high carbon pathways, the tasks of the analyst turns into applying path-dependency thinking in order to identify interventions that could set low carbon trajectories in motion. As such, the focus shifts from big “one-off” interventions that are supposed to solve a problem comprehensively with one stroke, or to a policy-mix that seeks to set all relevant elements into place at one time, towards more limited, fragile or small-scale policies that may over time increase support for policies addressing climate change (Levin et al. 2012, 124).

There are many instances where scholars evaluate specific policies, practices and initiatives related to decarbonisation efforts with reference to their rather proximate consequences. A such, these may be evaluated, in economic terms, in accordance with their perceived effectiveness or efficiency, or, from a political economy perspective, with regard to their political feasibility or whether they manage to generate support for more ambitious climate action. Many of these evaluations are formally correct, at least as long as one only focusses on a rather limited time frame. Now, any meaningful evaluation needs to relate to a somewhat limited time frame. The future is uncertain and the farther we gaze into
the future, the more uncertain it gets. However, I will show that in many cases a longer time horizon allows us to see how seemingly ineffective approaches, perhaps even those that may only have been intended as forms of greenwashing, or those that by themselves have failed to mobilise support for further ambitious environmental policy, can still contribute towards establishing potentially important conditions for advancing decarbonisation efforts.

In order to evaluate the contribution of policies and initiatives towards fostering the emergence of political support for more ambitious climate action, we need to understand how they can contribute towards the commensurability of carbon emissions and, thereby, the reconfiguration of incentive structures. By connecting the arguments made in the different chapters, one can see how the combined effects of different policies and initiatives can jointly help to improve the technical and political feasibility of reform towards a more effective global climate governance. Instead of merely waiting for policy consensus at the national, regional or international level, such insights may allow actors in different organisations and at different levels to align their actions in a polycentric manner, with a view towards progressive reform. For example, incentives for the provision of EPDs in one jurisdiction can increase the availability of EPDs in another jurisdiction. In this way, action in one jurisdiction can increase the technical feasibility of action in another one.

I introduce a focus on the informational side-effects of policies into the climate policy discussion and propose this as a new evaluation criterion, which can be used to gauge the degree to which policies contribute towards an increase in the feasibility of consumption-based approaches to climate policy. My study highlights the indirect – and often unintended – effects many policies and initiatives have on the supply of and demand for information relevant for quantifying the emissions embodied in products. My results point to the importance of thoroughly taking into account the informational dimension when evaluating the contributions of policies and initiatives to tackling the problem of climate change. These insights should inform forward-thinking policy designs and the orchestration of climate action.

To summarise: I posit that polycentrically distributed policies and initiatives have informational externalities that jointly contribute to the greater commensurability of the emissions embodied in products. Such greater commensurability enables embodied emissions policies, which can serve as decentralised mechanisms of mutual sanctioning in polycentric climate governance. The availability
of mutual sanctioning mechanisms increases the probability of successfully mov-
ing the atmosphere along the continuum from open access to jointly managed common property, thereby improving the sustainability of use. Greater com-
mensurability of the emissions embodied in products opens up new ways of framing the virtue and vice of products as well as of regulating them, which permits the rise of novel actor constellations advocating for embodied emissions policies. This has the potential to propel forward the implementation of sanc-
tioning mechanisms in the form of embodied emissions policies. The adoption of such a perspective radically alters the criteria in accordance with which one evaluates the contribution of diverse, polycentrically distributed, polices and initiative to global climate governance.
2. The problem of governing carbon emissions embodied in trade

We need to recognize that doing nothing until a global treaty is negotiated maximizes the risk involved for everyone.

— Elinor Ostrom, *Polycentric systems for coping with collective action and global environmental change*

The failure of the recent international climate change negotiations’ milestone agreements, the Copenhagen Accord and the Paris Agreement, to mandate binding emissions reductions for a sufficiently large share of greenhouse gas emitters raises the question of how states can pursue stringent climate policy in a world where economic competitors may not feel obliged to reciprocate their emissions reductions. Be it measures promoting renewable energy, imposing carbon constraints or radical energy efficiency standards – climate mitigation efforts only too easily run the danger of being stifled by the threat of foreign competitors not being subject to the increases in production costs that can result from climate policies.

At the same time the framework in accordance to which emissions reduction targets are set under international agreements is problematic to the extent that it excludes the emissions associated with the production of imported products and services from national accounts.

In the following I will argue that the capacity to take embodied emissions into account has the potential to decisively improve the governance of the global atmosphere and to raise the ambition level of climate action. I will do this by drawing on the theoretical framework concerned with the successful polycentric governance of common-pool resources associated with the work of Elinor and
2. The problem of governing carbon emissions embodied in trade

Vincent Ostrom (2014b), complemented with economic theory on carbon leakage and border carbon adjustments.

This chapter sets out the central concerns of the thesis. It makes the case that consumption-based policies targeted at embodied emissions have a great potential for moving the atmosphere along the continuum from the situation of open access towards a jointly managed common property. Consequently, it becomes of interests how embodied emissions policies can be brought about, both from a technical as well as from a political perspective. The next section discusses some of the shortcomings of the production-based approach to the attribution of greenhouse gas emissions to countries and presents some advantages of consumption-based approaches. Section 2.2 presents the rationale for the adoption of a a polycentric common-pool resource framework to the governance of the atmosphere. From the perspective of this framework, I argue that the lack of mutual sanctioning mechanisms is a major gap in the existing global climate change governance architecture. Section 2.3 then concretises that claim by relating it the discussion on carbon leakage. Section 2.4 presents, first, the promise of consumption-based policies for addressing carbon leakage and, second, the technical and political challenges in their way. Section 2.5 argues for the importance of gaining a better understanding of how diverse, polycentric policies and initiatives create nested informational externalities, which improve the monitoring capacities needed for mutual sanctioning mechanisms. Section 2.6 first provides an overview of different types of carbon reporting and disclosure and then demonstrates the significance of the argument that carbon labelling has the potential to considerably improve global climate governance by engaging with the critics of environmental disclosure and carbon labelling. Section 2.7 argues for the importance of understanding the dynamics by which greater demands for embodied emissions policies can be brought about and points to instances where actors advocate for novel types of policies addressing the emissions embodied in products. The remaining thesis examines how the informational and political conditions for implementing consumption-based policies have been significantly improved due to the informational externalities arising from polycentric policies and initiatives.
2.1. Production- versus consumption-based approaches to the attribution of greenhouse gas emissions

The United Framework Convention on Climate Change (UNFCCC) attributes the responsibility for greenhouse gas emissions to countries in accordance with the geographic origin of their release. This is known as *production-based* accounting. An alternative to this could be *consumption-based* accounting, i.e. the attribution of emissions on the basis of a country’s carbon footprint (Jakob et al. 2014, 301; Steininger et al. 2018, 226f.).

In 2004 about one-fifth of global emissions were embodied in goods and services traded between countries. Whereas industrialised countries are typically net importers of emissions, developing countries are typically net exporters (Jakob et al. 2014, 302).

The UNFCCC stipulates common but differentiated responsibilities in the fight against global warming. In the Kyoto Protocol these responsibilities were enshrined in limitations on the admissible amount of greenhouse gas (GHG) emissions directly emanating from within the borders of countries. Likewise, the Paris Agreement also assumes the GHG reductions to be pledged in the form of Nationally Determined Contributions (NDCs) as those arising within national borders (Karakaya, Yılmaz, and Alataş 2019, 16683). However, there are important arguments in favour of complementing the prevailing production-based perspective of the UNFCCC with a consumption-based perspective. For the sake of brevity the following exposition will limit itself to a number of key aspects: the consumption-based perspective as a prerequisite for the holistic attribution of carbon emissions to countries, climate justice, the inclusion of emissions from international transport, and the opening up of novel policy options that are associated with a consumption-based perspective.

A consumption-based perspective provides an important complementary perspective on whether countries are being successfully weaned off carbon intensive consumption-patterns. In some cases, taking a production-based perspective alone suggests some progress in this regard, whereas a consumption-based perceptive can offer an important and more holistic correction to premature conclusions of progress. While many industrialised countries have successfully managed to reduce their production-based emissions, once consumption-based emissions are taken into account, these improvements are far less pronounced, or are even more than offset. For example, analysing emissions embodied in trade
2. The problem of governing carbon emissions embodied in trade

during the period from 1990 to 2008, Peters et al. (2011, 8903) find that “net emission transfers via international trade from developing to developed countries ... [exceeded] the Kyoto Protocol emission reductions”.

From a climate justice perspective industrialised countries, who have disproportionately contributed to global warming, should bear more of the costs for global warming mitigation than developing countries. Where GHG intensive production relocates across countries but consumption patterns remain highly carbon intensive in affluent countries, a solely production-based accounting perspective may lead to an unwarranted appraisal of those countries’ global warming mitigation efforts. A consumption-based perspective could prevent that industrialised countries benefit from the relocation of carbon intensive production to developing countries in terms of a greater remaining carbon budget and instead allocate more of the remaining carbon budget to the developing countries (Afionis et al. 2016, 6). From a climate justice perspective it may be preferable to take consumption into account and opt for a relatively low consumption-level for industrialised countries in order to take into account their historical responsibility as expressed in the principle of common but differentiated responsibilities.

Developing countries, who tend to be net exporters of emissions, would benefit from a consumption-based accounting framework as it would shift responsibility for a part of production-based emissions to the importers. However, developing countries may suffer economically from the measures taken by emission importing countries to address their consumption-based emissions (Scott and Barrett 2015, 155).

The UNFCCC’s production-based accounting approach so far excludes emissions from aviation and shipping from the calculation of emission reduction commitments (Gehring and Robb 2013, 10). Under the production-based approach the problem of how to allocate international transport emissions has remained unresolved. Under this approach there are contradictions between the principle of equal treatment for vessels and planes\(^1\) and the principle of ‘common but differentiated responsibilities’, which is central to the international climate change negotiations. Any inclusion of international transport emissions from shipping and aviation would need to bridge these contradictions, for example with the introduction of specific funds for developing countries (Miola, Marra, and Ciuffo 2011, 5495). Afionis et al. (2016) suggest that a consumption-based approach to emissions accounting could avoid such contradictions by simply allocating

\(^1\)Under the flags of different countries and with different points of origins and destinations.
transport emissions to the consumers of the transported good in question.

Once consumption becomes a focus of mitigation policy, a range of novel options for emissions reduction strategies also come into view (Scott and Barrett 2015, 155), for example border carbon adjustments, green public procurement targeting embodied emissions, and embodied emissions standards. There is a correspondence between consumption-based accounting and consumption-oriented policies: the availability of consumption-oriented policies as a solution makes consumption-based accounting a more attractive way of assessing the problem and consumption-based accounting frames the problem in a way that calls forth consumption-oriented policies as an adequate solution.

Such novel policy tools would integrate better with important aspects of the logic in accordance to which many common-pool resources have been successfully governed. More specifically, consumption-based policies could add much needed possibilities for polycentric sanctions against governments that do not sufficiently cooperate on climate change mitigation.

Consumption-based approaches are, on the one hand, measures to reign in consumption-based emissions. On the other hand, novel consumption-based instruments may also help to bolster the ambition of existing instruments as they can help to reduce the threat of carbon leakage. In this way they can also be used to enable more stringent unilateral action in a context of polycentric climate change governance, thereby also helping to reduce production-based emissions.

2.2. Adopting a polycentric common-pool resource framework to the governance of the atmosphere

In the following I will draw on research on small and medium scale common-pool resources as well as on the notion of polycentric governance to argue for the importance of introducing graduated decentralised sanctions to the governance of the atmosphere.

Ostrom (2010c, 551) takes on the ‘conventional’ theory of collection action (see e.g. Hardin 1968), which predicts that in the absence of an external authority imposing enforceable rules no one will voluntarily reduce GHG emissions. She bases her questioning of the conventional theory of collective action on two pillars: first, she claims that the conventional theory of collective action fails to be empirically supported in “small to medium-size environmental dilemmas”.

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Second, she argues that there are multiple benefits at small, medium and large scales besides the reduction of GHG emissions at the global level, which need to be taken into account for a better understanding of the global warming collective action situation (E. Ostrom 2010c, 551).

Concerning small to medium-size environmental dilemmas Dietz et al. (2003, 1907) note that “many social groups ... have struggled successfully against threats of resource degradation by developing and maintaining self-governing institutions”. Amongst the factors enabling effective commons governance, Dietz et al. (2003, 1908) note a relative ease of resource use monitoring, relatively low cost of excluding outsiders from using the resource, and user support for monitoring and rule enforcement.

A fully-fledged exposition of Ostrom’s design principles is beyond the scope of this section but at least two important principles in the successful governance of common-pool resources should be addressed here: graduated sanctions and mutual monitoring. Amongst the advantages of polycentric systems Ostrom (2010c, 552) notes their mechanisms of mutual monitoring. Crucially, monitoring can inform the application of sanctions. For Ostrom (2014a, 182f.), the availability of graduated sanctions for rule violation is among the core principles for the successful long-term survival of institutions developed by resource users (see also Dietz, Ostrom, and Stern 2003, 1909; E. Ostrom 2014, 104f.). This is in stark contrast to the “[d]ifficulties of sanctioning [which] pose major problems for international agreements” (Dietz, Ostrom, and Stern 2003, 1909).

The applicability of Ostrom’s design principles for common-pool resources to climate change action is far from obvious. Crucially, there are no relevant outsiders to the use of the atmosphere and, in principle, everybody is entitled to the use of this resource. This may account for the curious fading away of the issue of sanctions in Ostrom’s writings on climate change. In an early paper dealing with climate change McGinnis and Ostrom (1992, 24f.) state that “a preliminary focus on monitoring and sanctioning activities seems warranted by their fundamental importance for any effort to achieve meaningful and sustainable changes in the level of international cooperation.” In her World Bank report on *A polycentric approach for coping with climate change* and the subsequent article Ostrom (2009, 12, 36f.; E. Ostrom 2014) writes about the importance of sanctioning mechanisms for solving common-pool resource dilemmas below the level of the global common. Yet, she does not suggest any ways of developing

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2On sanctions see also Agrawal (2002, 54f.).
2.2. Adopting a polycentric common-pool resource framework to the governance of the atmosphere

sanctioning mechanisms for the area of climate change governance (just as in E. Ostrom 2010a). Instead, she switches from the common-pool resources frame to a stronger emphasis on polycentric governance. In *Polycentric systems for coping with collective action and global environmental change* (E. Ostrom 2010c), unlike in many of her prior writings, she does not even mention sanctions as a crucial factor for successful common property regimes but strongly emphasises the potential advantages of polycentric governance.

As we can see, in her later papers Ostrom does not directly address the lack of sanctioning mechanisms in climate change governance. This is in stark contrast to her other writings and could potentially be rooted in the difficulty to exclude nations from using the atmosphere, the circle of appropriators not being limited. In line with this reading, Levin et al. (2012, 136) argue that Ostrom’s design principles for sustainable resource use are not applicable to the ‘super wicked problem’ of climate change, which is marked by the impossibility of excluding populations from emitting greenhouse gases into the atmosphere. However, just because one cannot exclude others from ‘using’ the atmosphere, it does not follow that sanctions are not available. For one can reduce the size of the market for carbon intensive products, and do so with transnational effects.

It is instructive to recall that Hardin’s (1968) Tragedy of the Commons, which is perhaps the by now archetypal version of the ‘conventional approach’ to the problem of common-pool resource management, against which Ostrom pitches her approach, was criticised for confusing the concept of common property, signifying the joint management of an open access resource, with that of open access conditions, which are characterised by the absence of rules limiting who can use a resource, and to what extent (Dietz et al. 2002, 11, 17; Rose 2002, 234).

A ‘common-pool’ resource is one from which it is difficult to exclude users. It may be left as open access, administered by a central authority, parcelled up into private property or jointly managed in the form of a common property regime (Dietz et al. 2002, 17). With regard to the emergence and implementation of common property regimes one can further distinguish between a successful prior agreement on the basic rules of how the property is to be held in common use or the emergence of rules over time, based on the repeated interactions of an ensemble of actors initially pursuing varied practices. The latter option fits some of the characteristics of what has been described as polycentric governance in global climate politics.

If the atmosphere is left as open access, the danger is high that it will fall
2. The problem of governing carbon emissions embodied in trade

victim to the ‘tragedy of the commons’. The failed diplomatic efforts to reach an international agreement that stipulates how much any one nation can pollute, complete with centralised sanctions, along the lines of the Kyoto Protocol, can be seen as an attempt at establishing a form of central authority for the administration of the atmosphere as a common-pool resource. Such a central authority can then provide the basis for the parcelisation of the atmosphere into private property in the form of tradeable emissions permits. A privatisation without the prior establishment of central authority will, however, remain incomplete. The failure to establish such central authority, the corresponding limitations for privatisation, and the bleak outlook of leaving the atmosphere in a state of open access call for the establishment of a common property regime.

Without the setting of rules that limit its use, the atmosphere remains in or reverts back to the stage of open access. In this sense, the introduction of sanctioning measures to prevent business and governments from fully enjoying the commercial benefits from their open access to the atmosphere could be seen as an indirect way to limit, if not access to the atmosphere itself, at least access to some of the potential economic benefits accruing from it. Doing so would help to shift the atmosphere along the continuum from open access towards a common property resource.

To add conceptual clarity, it helps to stratify the concept of resource use (Figure 2.1). First, there is a general ‘use’ of the atmosphere as a ‘sink’ for the emission of greenhouse gases. Second, there is the use of the atmosphere’s sink function for commercial purposes. Third, the atmosphere’s sink function can be used via its commercial exploitation in relation to export markets. Actors at multiple levels of governance can targets this subset of use via monitoring and sanctioning mechanisms.

For Ostrom (1999, 506), the efforts of resource appropriators directed at designing rules for the management of common-pool resources contribute to the creation of a public good for all involved (see also Hess and Ostrom 2003, 117). Hess and Ostrom (2003, 117) present three layers of public goods:

1. the one to be sustainably appropriated as a resource,

2. the organisation of rules, rights and duties for resource appropriators, and

3. investment in monitoring and sanctioning activities that back up the rule-following.
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Figure 2.1.: Stratified use of the atmosphere’s sink function

Depending on the type of rule (second layer), the availability of information on the emissions embodied in products (third layer) may be a prerequisite for the meaningful enactment of such a rule. Dietz et al. (2003, 1909) note that “the ability to choose institutional arrangements depends in part on [monitoring] infrastructure”, which is a partial analogue to Esty’s (2004) statement that information enables new policies. In such a case it therefore makes sense to conceptualise governments, businesses, consumers and civil society demanding and supplying information on the emissions embodied in products as contributing to the creation of this third layer of public good.

According the Dietz et al. (2003, 1908) adaptive governance in complex systems requires the availability of information on the resource systems being governed at a scale that is congruent with relevant environmental events and decisions. Transferring their insights to the domain of climate governance, a case arises that information should mirror transnational production networks. The provision of such a monitoring infrastructure could be regarded as a contribution to the generation of a public good. In the same vein, the introduction of consumption-based approaches — which also have an element of sanctioning non-cooperative behaviour in a rules-based way — should be appreciated as a contribution to public good creation.

With polycentrically emerging rules based not on consensual agreement but on unilateral or club action, there are some difficulties with regard to attributing the quality of being a public good. For once, they develop without the consent
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or even against the resistance of certain resource appropriators. To the extent that these still benefit from the outcome in terms of greater availability of the resource in question, they do benefit from a public good. However, if rules are imposed on resource appropriators against their will, would it not be misleading to call this a public good?

To what extent one can call the second and third layers public goods in the presence of asymmetric and not fully consensual rule creation processes is somewhat ambiguous. For example, Hess and Ostrom (2003, 117) suggest that “investing in monitoring and sanctioning activities to increase the likelihood that participants follow the agreements they have made also generates a public good” (emphasis added). This implies that the rule-takers are also rule-makers. It is however common in international relations theory, and here in particular in regime theory, to talk of public goods regardless of whether there is consent regarding the desirability of the public good and the means by which it is achieved (Kindleberger 1986). The same goes in the domestic realm, where police protection is seen as public good, even if not everybody has chosen to be policed (Olson 1975, 14).

The next section presents carbon leakage as a major problem for climate governance, which could be alleviated by the use of consumption-based policies as a form of sanctioning instruments. Monitoring possibilities are crucial for the implementation of this category of sanctioning instrument. Thereby two of the major missing elements in Ostrom’s set of design principles will be addressed.

Subsequently, I will reframe Ostrom’s emphasis on the multiple benefits climate action can already have even in the absence of a global regime. First, I will argue that a diverse range of policies and initiative generate benefits in the form of informational externalities, which facilitate mutual monitoring and thereby, indirectly, the availability of sanctions. Second, I posit that sanctions, in the form of consumption-based instruments targeting embodied emissions, can confer competitive advantages to groups of relatively low carbon producers and service providers. The prospect of such benefits can motivate companies to push for policies tackling embodied emissions.
2.3. Carbon leakage as a problem for governing the atmosphere as common property

This section shows how the spectre of carbon leakage greatly undermines the promises of carbon pricing, which has severe knock-on effects on the capacity of states to radically cut emissions.

So far, the major instruments for mitigating global heating in industrialised countries have consisted in policies seeking to increase energy efficiency, supporting the roll-out of renewable energy, and carbon pricing. Energy efficiency measures can have significant co-benefits, which make them attractive even in the face of non-cooperation of other countries. However, efficiency measures alone do not suffice for tackling the climate challenge. Furthermore, they may lead to ‘rebound’ effects, or can even ‘backfire’ (Sorrell 2009a). The rollout of renewable energy is of enormous importance for tackling climate change. In line with Ostrom’s emphasis on secondary benefits it can also have co-benefits in terms of cleaner air and energy independence. However, rapid rollout of renewable energy and substitution of fossil fuel energy is expensive and, if not reciprocated by trading partners, can lead to competitiveness losses. There are also leakage problems, e.g. when one country reduces its demand for fossil fuels, other countries can enjoy a lower price on the world market (see below). Carbon pricing should, in principle, create incentives for both improvements in energy efficiency and a transition towards renewables. Similarly to the roll-out of renewable energy, the ambition to price carbon is seriously inhibited by competitiveness concerns and, associated with that, the leakage effect. This section focuses on the promise of carbon pricing and how the spectre of carbon leakage keeps its potential from being realised. While there are many parallels and linkages to the rollout of renewable energy, here I focus on carbon pricing as it is more intricately related to carbon accounting, which forms the basis for the consumption-based policies that may plug the gap left by the missing sanctioning mechanisms in climate change governance.

In 2005 the EU launched its greenhouse gas emissions trading system (EU ETS) (European Commission 2015, 4), eventually described as the “EU’s flagship policy to combat climate change” (European Commission 2017a). California passed A.B. 32 law in 2006, leading to the creation of a GHG cap-and-trade system (Richardson 2012, 8). By 2018 51 carbon pricing initiatives had been implemented or were scheduled for implementation (World Bank and Ecofys...
For most climate economists carbon pricing is the preferred approach towards climate change mitigation efforts. They tend to see carbon emissions as an externality, in the sense that people do not pay the full social costs of what they consume. From this perspective it makes sense to add the apparently missing element to their calculation: costs (Helm 2012, 176f.; Nordhaus 2013, 222; Grubb, Hourcade, and Neuhoff 2014, 303; Stern 2015, 111).

A carbon price promises to exert behavioural effects on three important groups of people: Consumers would adjust their buying behaviour in accordance with a modified price structure and thus consume less carbon intensive goods. Producers would seek to save money by reducing the carbon intensity of production. And innovators would seek out new ways to reduce the carbon emissions associated with products and services (Nordhaus 2013, 224f.).

Regarding the question of where in the chain of production prices should be levied, Nordhaus (2013, 223), e.g., makes the case that it would be the most economical to charge suppliers of fossil fuels or the upstream emitters for carbon emissions, rather than downstream users. The economic ‘elegance’ of this is an important argument underlying the real world design of carbon pricing systems (Nordhaus 2013, 224). A related argument in favour of a carbon price is that it would help to economise on the information required to make climate-friendly decisions by making sure it is already incorporated into market prices, rather than people needing to rely on the availability of information on carbon emissions associated with the plenitude of activities along the entire production chain that are implicated in the production of goods and services, and having to conduct complicated calculations, be it for making decisions about regulating industries or for their own consumer behaviour (Helm 2010, 193; Nordhaus 2013, 226f.). Here the promise is that a relatively simple instrument would help to greatly reduce the complexity involved in transitioning to a low-carbon economy.

This economising on informational requirements corresponds to a governing at a distance (Miller and Rose 1990), where government seeks to set general framework conditions instead of directly prescribing the adoption of certain practices or technologies. When praising the information economising properties of market-based mechanisms for climate mitigation, Helm (2010, 193) refers to Hayek, who frames competition as a procedure for discovering knowledge that is dispersed among people. For Hayek (1990, 181f.):

“Utilisation of knowledge widely dispersed in a society with exten-
2.3. Carbon leakage as a problem for governing the atmosphere as common property

Savage division of labour cannot rest on individuals knowing all the particular uses to which well-known things in their individual environment might be put. Prices direct their attention to what is worth finding out about market offers for various things and services.”

In a similar spirit Goulder and Parry (2008, 157) advocate for market-based mechanisms in environmental policy, with reference to the informational disadvantages faced by the regulator:

“Compared with emissions taxes and tradable emissions allowances, direct regulations such as technology mandates and performance standards are at a disadvantage in meeting the conditions for cost-minimization. The disadvantages reflect information problems faced by regulators as well as limitations in the ability of these instruments to optimally engage the various channels for emissions reductions.”

In this vein, the idea of the EU ETS, for example, is exactly not to pick winners and losers of regulation but to leave it up to industry to come up with the most effective mitigation measures. Here, the European Commission seeks to govern at a distance, to mobilise dispersed knowledge via the price mechanism.

This apparent avoidance of picking winners or losers is guided by the concept of technology-neutrality. According to this precept, government should set general framework conditions but not privilege any particular technology over another (for critical perspectives see Azar and Sandén 2011; Mazzucato 2016). This can make sense, in particular where one expects innovation to contribute solutions towards problems such as climate change mitigation. The relative mitigation potentials of different technological pathways are not known in advance, and the regulator’s knowledge is limited.

Market-based mechanisms not only promise to be neutral with regard to the ways in which one achieves emissions reductions but also in the face of demands from competing interest groups. The application of neo-classical economics to public policy seeks to, ideally, exorcise private influence from political decisions or, where it cannot completely do away with it or concedes some dependence on it, neutralise it by eliciting advice from private actors within an institutionally optimised framework of heightened pluralism (Streeck 2006, 27). In this vein, Helm (2010, 193) suggests the use of market-based instruments in order to limit

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3Interview with EU ETS expert from DG CLIMA in August 2016.
2. The problem of governing carbon emissions embodied in trade

the possibilities for capture of the policy process by organised interests. He notes that “market-based instruments economize on the amount of information needed” by the regulator, thereby mitigating the impact of the informational asymmetries between the regulators and the regulated.

Despite all these promised qualities, carbon pricing systems – as currently implemented – suffer from a logical succession of problems that are either due to or are aggravated by a common core problem: the spectre of carbon leakage.

Ostrom (2010c, 554f.) already noted the problem of carbon leakage in climate change governance. Weak, or demand-driven, carbon leakage occurs independently of climate policy and is either due to companies relocating polluting production abroad in pursuit of advantages such as lower wages or non-climate related regulatory compliance costs, or to increasing imports from foreign companies with higher competitive advantages, such as lower costs or higher quality. In contrast, strong carbon leakage refers to the policy-induced relocation of carbon emissions (Peters et al. 2011, 8907; Afionis et al. 2016, 3f.; Sakai and Barrett 2016, 102). In the following, the term carbon leakage exclusively refers to such strong carbon leakage.

Unilateral climate policies may result in strong carbon leakage via the following three mechanisms (Jakob et al. 2014, 300):

1. Energy market or supply side leakage: Climate policy in one part of the world leads to decreased demand for fossil fuels and a subsequent decline in their world market prices. This stimulates increased fossil fuels consumption in parts of the world with weaker or non-existent climate policy.

2. Specialisation leakage: climate policy increases the price of emissions-intensive goods produced in the area targeted by it, which increases demand for relatively cheaper goods produced outside its target area and thereby shifts emissions from the area with climate policy to the area without (or from strongly to weakly regulated areas). The tragic aspect of the carbon leakage scenario is that the continued consumption of the good in question, now relocated abroad, means that all or part of the intended reduction in consumption fails to materialise, which would make the policy largely ineffectual for reducing GHG emissions (Grubb, Hourcade, and Neuhoff 2014, 204f.; Tirole 2012, 122).4

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4To what extent this really is a case for different industries and carbon price levels is a highly politically charged matter of contestation.
2.3. Carbon leakage as a problem for governing the atmosphere as common property

3. *Free-rider* leakage: unilateral emissions reduction efforts are welcomed by other countries as the voluntary provision of a public good. Yet they may not reciprocate but, instead, decrease their own provision of the public good in question, i.e., emit more than they would have without the unilateral emissions reduction efforts.

These mechanisms are likely to interact and thereby make the overall leakage problem more severe.

Free-riding is a more general problem beyond the limited case of free-rider leakage. Resource users who cannot trust that others will abstain from free riding will be less inclined to restrain their own resource consumption (Ostrom 2012, 365), which inhibits both unilateral emissions reductions and adherence to shared norms. Ostrom (2010c, 555) notes that free riding is an “important threat to a system that evolves without the presence of an enforceable treaty” but that free riding could also occur in the presence of a global treaty. More specifically, she questions whether a global climate policy would be able to sufficiently generate trust in citizens and firms that their counterparts in other regions would reciprocate any emissions mitigation actions. In this context, she suggests the value of lessons learnt from forest governance, where forests tend to be in better conditions when users monitor each other. And, according to her (Ostrom 2012, 365), in the realm of climate governance,

“Effective monitoring is needed both to catch offenders as well as assuring those who cooperate with costly policies that they are not suckers.”

The use of the term ‘suckers’ in discussions of the determinants of cooperative behaviour suggests an underlying game theoretical rationale. When one plays such a ‘climate game’ without a dedicated sanctioning mechanism, however, the best strategy for avoiding to become a ‘sucker’ and still have a chance of achieving climate goals would be to play tit-for-tat, i.e. reciprocate the other player’s action, and always communicate that one would be willing to opt for mitigation action if the other player is willing to reciprocate (Axelrod 1984, 19f.; Paterson 2014, 49). In the case of the Paris Agreement’s ratcheting up of NDCs, to which the hope is attached that ambitious commitments of some would spur the ambition of others, but which lack any dedicated legal sanctioning mechanisms, the only feasible sanctioning mechanism apart from ‘naming and shaming’ (Wolfgang Obergassel (né Sterk) et al. 2016, 243) seems to lie in the withholding
of mitigation action. However, in the domain of climate governance, it could be highly counter-productive if resource ‘users’ withhold their own mitigation efforts in response to others’ failure to mitigate emissions in a tit-for-tat type of game. Where time is a crucial factor and the boundaries between cooperation and defection are blurry, it seems too risky an option to wait for a cooperative equilibrium, not to speak of the desired ratcheting up, based on the logic of tit-for-tat. In particularly, when other players are not inclined to cooperate regardless of one’s own actions, tit-for-tat is ultimately doomed to failure.

The potential for free-riding aggravates the spectre of specialisation leakage. As a consequence, the promises of carbon pricing fail to (fully) materialise. Anticipating the threat of policy-induced specialisation leakage, policy-makers become wary of exposing those industries they deem at risk of carbon leakage to the full burden of high carbon prices. Once they implement measures to shield industries considered to be more at risks of carbon leakage from the full brunt of the carbon price, they begin to discriminate between different producers and thus the principle of technology-neutrality becomes compromised. Where industries are protected from feeling the pressure of the carbon price, the forces of ‘creative destruction’ (Schumpeter 2003, 81ff.) remain neatly leashed up in the kennel and innovation activity muted. Another implication is that the government needs to obtain information on the risks of carbon leakage from the regulated industries, which then opens up opportunities for the regulated industries to play out their informational advantages over government and the general public, making regulatory capture more likely.

A major factor that limits real existing carbon pricing’s ability to more closely resemble the theories of economists is the lack of technological neutrality which can serve as a driver for innovation. Of course, the overall lack of effectiveness, due to the low level of the carbon price, is also of concern, yet this concerns more the magnitude of its effect rather than its qualitative attributes.

From the lack of technological neutrality follows the other aspect where the empirical manifestation of carbon pricing falls short of economists’ ideal: the lack of the ability to remain even-handed in the application of the carbon price, which subsequently opens the floodgates to regulatory capture. The lack of industry support for ratcheting up the carbon price is, of course, also a political economy problem, yet it does not put in doubt the principal merits of carbon pricing.

Let us now look at each of the different points in turn: distortion of technology-
2.3. Carbon leakage as a problem for governing the atmosphere as common property

neutrality by efforts to prevent carbon leakage, muting of innovation activity, opportunities for regulatory capture, and the lack of industry support for a ratcheting up of the carbon price.

Under the EU ETS and, in its wake, the Californian ETS (now linked to Quebec’s\(^5\)), industries considered to be energy-intensive and under the threat of carbon leakage are granted free allocation of emissions permits. For many industries this free allocation is based on the performance benchmarks of specific product categories. In deliberations about what should be benchmarked the European Commission is eager to find an agreement with the mainstream of industry voices.\(^6\)

For some of the benchmarked products, such as clinker and steel, an important share of emissions are process emissions from the chemical reactions involved in creating the materials in question. Increases in energy efficiency or the roll-out of renewable energy alone are not going to contribute to the mitigation of these emissions.\(^7\)

The amount of energy that the steel industry uses to produce a ton of steel is also becoming very close to the theoretical minimum needed. While the potential to further increase efficiency exists theoretically, it is very difficult to achieve further gains. Further improvements are likely to be quite small compared to the improvements the steel industry witnessed over the last few decades.\(^8\) As a consequence, most of the environmental impact reduction potential is located \textit{downstream} in the supply chain (see Appendix, Section A.5 for more background information on building materials).\(^9\)

Considerations of the special role of process emissions are part and parcel of the benchmark design and its on-going development (Secretary-General of the European Commission 2016, 3). As part of an update of the benchmarks all sector benchmarks are subject to a decrease, and thus facilities are entitled to less free allocation. However, the European Commission reasons that one cannot expect all sectors to decrease their emissions at the same rate, process emissions being one of the reasons. Due to the limited abatement potential of certain sec-

\(^5\)See Purdon, Houle, and Lachapelle (2014).
\(^6\)Interviews with EU ETS expert from DG CLIMA, cement and steel experts from DG GROW, cement industry expert Bruno Vanderborght.
\(^7\)Interview with steel and cement experts from the University of Cambridge.
\(^8\)However, in the mid- to long term renewable energy may be used to produce hydrogen, which could then be used to substitute carbon and thereby more radically decarbonise steel production (Otto et al. 2017).
\(^9\)Interview with steel expert from the University of Cambridge.
2. The problem of governing carbon emissions embodied in trade

tors, the European Commission has applied a lower down-adjustment of their benchmarks for free allocation than for other sectors (Erbach 2016, 5). The benchmark adjustments for industries with high process emissions are milder than the standard adjustment percentage. However, while the Commission acknowledges that some emissions are ‘unavoidable’, it is still of the opinion that all sectors should contribute to mitigation efforts.\(^\text{10}\)

Economists endow a carbon price with the hope that it provides the right incentives to decarbonise the economy not only in the most efficient way given the resources available at any moment in time, i.e. in a static way, but also by helping to stimulate the forces of innovation in order to come up with novel solutions to the challenges posed by climate change mitigation. Yet, by effectively bracketing out certain products from such a transformative endeavour and instead only promoting a greater efficiency in their production, rather than a potential substitution of certain products by others, radical innovation is reigned in, in favour of incremental improvements. Allocating emission permits based on benchmarking values fails to adjust incentives, stabilises the production of knowledge around existing products and thus locks in and even further entrenches extant industrial innovation trajectories. Rather than shifting the focus towards the creation of novel low-carbon products, the focus remains on incremental progress in reducing the GHG intensity of existing products.

Benchmarking is framing the sphere of intervention and its perimeters as it determines which point of the supply chain is targeted. This is also driven by practical considerations, as regulating upstream helps to reduce complexity. However, this fails to target opportunities for carbon savings and innovation downstream.

Decisions over the amount of emission permits that are to be freely allocated can become victims of regulatory capture. The definition of what is to be benchmarked, i.e. which elements or what stages of the value chain, is a highly political act, with important implications for the innovation trajectories of some of the most carbon intensive industries. In benchmarking deliberations the European Commission consulted with the affected sectors directly and via policy consultants, who eventually came up with proposals for the benchmarks. In this process, the consultants had to take decisions on whether to recommend benchmarks for cement or clinker, cement’s carbon intensive precursor (Ecofys, Fraunhofer Institute for Systems and Innovation Research, and Öko-Institut

\(^{10}\)Interview with EU ETS expert from DG CLIMA in August 2016.
2.4. The promise of consumption-based policies

Grubb et al. (2014, 204f.) present three options for addressing ‘carbon leakage’:

“... ‘levelling down’ the price, by exemption or free allocation; ‘level-
2. The problem of governing carbon emissions embodied in trade

...ling up’ by establishing the same price on all such production globally; or levelling at the border (i.e. on imports and exports)’.

While the first option severely compromises the effectiveness of decarbonisation, for Grubb et al. the second approach, a globally unified carbon price, is highly unlikely to be realised any time soon. As such, the only option that is both effective and realistic is the third, a levelling at the border.

A border carbon adjustment (BCA) could not only be a way of limiting some of the negative effects of unilateral climate policy. It could also serve a strategic instrument to induce other countries to implement or strengthen climate policies (Jakob et al. 2014, 307).

Whereas global treaties may suffer from a lack of ambition and enforcement problems, a patchwork of consumption-based policies could locate enforcement in a more decentralised network, independently of a global consensus. In accordance with this logic, Rochi et al. (2018, 127) situate their advocacy of BCAs within Ostrom’s vision of a polycentric approach to climate change, where even without a global agreement, citizens as well as local and national authorities already begin unilateral action.

It thus seems to be a worthwhile endeavour to better understand the technical complexities involved and how they may be alleviated in order to make such levelling at the border more feasible. If environmental governance scholarship managed to contribute to this task, the prize would be enormous, indeed, as Grubb et al. (ibid.) call the lack of a border levelling mechanisms “an unresolved and growing problem which undermines the entire effort to price carbon”.

The problem of emissions embodied in trade and ‘consumption-based’ approaches towards tackling these have become a hot staple of the climate change literature (Davis and Caldeira 2010; Chen and Chen 2011; Harris and Symons 2013; Afionis et al. 2016; Neuhoff et al. 2016). There has been a lot of speculation on the effects of a turn towards consumption-based approaches in the governance of climate change and the literature has discussed a range of potential unilateral BCAs: for example border tax adjustments, the requirement that importers need to purchase emissions allowances, or carbon-related charges at the point of consumption (Helm, Hepburn, and Ruta 2012, 369; Grubb, Hourcade, and Neuhoff 2014, 294; Neuhoff et al. 2016). The present study does not delve into these rather abstract details but focuses on the empirical conditions.

12 However, see critical perspectives on the limitations of a BCA for tackling carbon leakage see Sakai and Barrett (2016) and Jakob et al. (2014).
2.4. The promise of consumption-based policies

for the emergence of what can be deemed organically emerging actual policies addressing embodied emissions, be they actually implemented, announced or merely advocated for.

After the failure of the Copenhagen climate summit in 2009, the French government was floating the idea of a ‘carbon inclusion’ mechanism, as a last resort in order to have a lever to revive international climate change negotiations. The carbon inclusion mechanism would have required importers into the European market to purchase EU ETS emission permits. In order to avoid complex calculations it was envisaged to estimate the carbon content of products based on European averages. Notably, the European steel industry association Eurofer supported the move, as a potential complement to free allocation, to further shield it from competitive disadvantages. While Italy supported the French advance, Germany and the European Commission were more wary and highlighted the risk of triggering a trade war with China (Simon 2010).

In February 2017 the US Climate Leadership Council sought to make “The Conservative Case for Carbon Dividends”, including Border Carbon Adjustments (Climate Leadership Council 2017). In the same month, in the run-up to the European Parliament’s vote on the EU ETS reform, including carbon border adjustment measures (BAM), steel giant ArcelorMittal advocated in favour of a carbon border tax (Mittal 2017).

However, Grubb et al. (2014, 204f.) suggest that the technical complexities and political consequences of border carbon adjustments are too daunting for regions to implement them. Correspondingly, the European Commission, or parts therein, point to limitations of proposals for the inclusion of consumption, both in terms of technical and political feasibility: An EU ETS expert from DG CLIMA remarked that the inclusion of consumption in the ETS would make the system similar to a border tax adjustment. This would be a completely different approach to the principle of free allocation. Yet, free allocation is already accepted by the industry and other stakeholders. The consequences of such a shift to a different model are unknown and it is unlikely that industry would support it. The proposal also seems too complex and the administrative burden seems disproportionate to the limited value added.13

The effective tackling of carbon leakage is likely to require detailed knowledge about the carbon embodied in products (Sakai and Barrett 2016, 104f.).

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13 Interview with EU ETS expert from DG CLIMA in August 2016; see also Helm and Hepburn (2017).
2. The problem of governing carbon emissions embodied in trade

Nordhaus (2013, 256f.) considers a border tax adjustment approach so overly complex that he suggests it may be preferable to erect a uniform tariff wall for countries who refuse to join the carbon pricing club. Tirole (2012, 128f.), while observing that the “theoretical rationale for [border tax adjustments] is impeccable”, points to drawbacks in their implementation, listing *inter alia* the difficulty to assess the carbon contents of goods produced in transnational supply chains. Helm et al. (2012, 391) also suggest “that the calculation of appropriate BCAs will be devilishly difficult”, yet they propose that one could start with a small number of key sectors, for which one could calculate carbon intensities relatively easily. One could also rely on standardised benchmarks for setting the BCA while giving producers the right to prove that they their goods are less carbon intensive and thus outperform the benchmark (Grubb, Hourcade, and Neuhoff 2014, 294; Helm, Hepburn, and Ruta 2012, 391).

According to Sakai and Barrett (2016, p.- 103), “the benefits generated by BCAs would be small, while its implementation could prove to be extremely costly and difficult”. An estimation of the benefits generated by BCAs depends on a range of assumptions and also on whether one takes a rather static or more dynamic view of the benefits BCAs may deliver. Sakai and Barret (2016) take a rather static, short term view, somewhat neglecting the importance of BCAs for a radical ratcheting up of carbon pricing and the discontinuation of free allocation. However, the implementation of BCAs would undeniably be costly and difficult, making it an important goal to reduce these hurdles and thereby increase the technical and administrative feasibility of this or similar policy options.

This thesis addresses both the technical and the political feasibility of BCAs and related consumption-based policies. Regarding the technical feasibility I analyse the effects of production-oriented policies and initiatives on the availability of consumption-based information. The latter could help to reduce the difficulties in implementing BCAs or, alternatively, low carbon product standards that take into account embodied emissions. Regarding the political aspects, I explore how the availability of information on embodied emissions has enabled the emergence of new coalitions which advocate for the adoption of embodied emissions policies that could serve as precursors to BCAs.

Starting a BCA small and simple and then expanding the scope of the intervention could be a potential pathway to tackling the problem of emissions embodied in trade. However, this approach would still require a significant trad-
2.5. The polycentric emergence of monitoring capacities

Tackling the problem of consumption is likely to require more than just a few quick changes at the national level. Any production-oriented cap-and-trade system requires monitoring, reporting and verification of emissions. Accounting for embodied emissions at the aggregate national level is already a huge challenge. Implementing a regime that allows to break embodied emissions down to the level of manifold products poses an even greater challenge. Including consumption would require a complex transformation of global commodity chains, probably with the same elements as those brought forward by Dauvergne and Lister (2011, 26) when discussing how to advance global timber sustainability: “chain of custody eco-certification, carbon accounting, and life-cycle assessments”.

PCFs address all of these aspects. Focussing solely on past developments, Van der Ven et al. (2017, 14) suggest that, so far, they mainly had impacts in terms of the BCAs and the EU. However, a comprehensive approach that includes embodied emissions in trade policy and other regions could only be pursued if the bloc, such as the EU, or an entire country outside such a bloc, to subscribe to it before a meaningful start could be made. Carbon pricing leaders among subnational actors such as California and Quebec and those of countries within the EU more eager to ratchet up climate policy, such as France, could only pursue this model once they can convince other actors to agree to incorporating embodied emissions in trade policy.

There are ways besides the actual adoption of BCAs that may already help to prepare the grounds for the eventual adoption of such measures. These options include measures to address the carbon embodied in products and services via standards, taxation incentives or procurement decisions.¹⁴

Having established that there is a range of potential policy instruments that take into account embodied emissions besides BCAs, I argue that these approaches can help to prepare the ground for BCAs, may work complementary to them, or provide alternative mitigation measures in lieu of the successful adoption of BCAs.

¹⁴To what extent are such measures distinct from BCAs? Helm et al. (2012, 369), in turn referenced by Afionis et al. (2016, 11), also include product standards that include embodied carbon as part of BCA. They base this on a reference to Wooders et al. (2009) but do not mention it again in their text. However, the author team of Cosbey et al. (2012, 7), which comprises the authors of Wooders et al. (2009), makes clear that BCAs always comprise price adjustments and see BCAs as distinct from “special treatment to vulnerable sectors ... international sectoral agreements ... GHG intensity standards, bilateral or regional accords”. It clearly makes sense to see GHG intensity, or embodied emissions, standards as analytically distinct from BCAs.
2. The problem of governing carbon emissions embodied in trade

of consumer and business behaviour. However, it is important to be aware of their potential for public policy. Echoing a review of the literature, Afionis et al. (2016, 14) suggest that “the standardization of product footprinting would need to be improved to move from the voluntary reporting of embodied emissions to enable the regulation of embodied performance standards”. This raises the question of which processes have so far led to a greater standardisation of product footprinting?

One approach towards improving the conditions for consumption-based approaches could be to strengthen the capacities to attribute embodied emissions to products, their ‘carbon footprint’. Many producers of carbon intensive products already offer EPDs that comprise such a carbon footprint (Institut Bauen und Umwelt 2018b). In 2016 Martin Baitz, Director Content at major LCA database and tools provider Thinkstep AG suggested that, in the future, LCA databases, which incorporate EPDs as well as provide data for them, may serve “as a basis for legal regulations” (in Prox 2016a). Ramon Arratia (2012, 74), during his tenure as European Sustainability Director for InterfaceFlor, suggested that “EPDs enable policy-makers to see fully transparent data about the real impacts of products – such as their embodied energy … and therefore to introduce taxes on this basis”. As we will see in the subsequent chapters, a range of other actors hold similar views. The wide diffusion of EPDs could ease the administrative burden for different consumption-based approaches, for example the inclusion of consumption into the ETS, as suggested by Neuhoff et al. (2016).

How can the necessary capacities for monitoring the emissions embodied in trade be brought about? A burst of newly emerging transnational institutions is (re-)shaping governance in a range of sustainability-related areas, including that of the climate. The emerging system of transnational climate change governance is composed of various actors, “from business firms to city governments to varied combinations of public and private stakeholders”, including states and interstate organisations (Abbott 2012, 571f.). Many of the actors engaged in transnational climate change governance operate or contribute to voluntary forms of ‘regulatory standard setting’. This is largely driven by nonstate actors with other nonstate actors as their targets (Abbott 2012, 572). Abbott (2012, 572) argues that these actors should be considered institutions of governance as they provide collective goods, enact norms and influence other actors.

Abbot analyses transnational climate change governance in terms of regime complex theory (Keohane and Victor 2011) and polycentric governance the-
2.5. The polycentric emergence of monitoring capacities

ory. Whereas regime complex theory’s core arguments focus mostly on interstate regimes and are mainly concerned with legally binding rules (Abbott 2012, 572), polycentric governance theory is rooted in the analysis of the management of common-pool resources and environmental change (E. Ostrom and Ostrom 2014b). Abbot (2012, 578) argues that a combined mapping of the transnational climate change governance landscape and the climate-related interstate regime would reveal the true climate change regime complex.

Cole (2015, 115) frames the “numerous climate policies that have been, and are being, implemented at local, state, regional and national governments, and even among private business associations [as] .. polycentric policies”. Amongst the advantages the proponents of polycentric approaches to the management of common-pool resources claim over concentric approaches are that the former provide more opportunities not only for mutual monitoring, communication and trust-building but also for learning and experimentation which, over time, may lead to the adaptation of better strategies for reaching effective collective action (E. Ostrom 2010c, 552; Abbott 2012, 586; Cole 2015, 114f.).

Abbott (2012, 586) particularly emphasises that polycentric governance theory helps to better understand the contribution of information and networking schemes. He calls for further research to assess “the effectiveness, normative impact, and distributional consequences of these diverse schemes and activities” (Abbott 2012, 580). Yet, the focus on effectiveness needs to be extended towards effects, to better understand how these diverse polycentric activities may help to improve the structural conditions for managing the atmosphere as a common property.

For the purposes of the argument here, I claim that, in particular, these diverse polycentric activities have contributed to greater information about the impacts embodied in products, which may be related to both communication and trust-building. In this sense, there have been polycentric activities, which have generated feed-forward effects in terms of the viability of policies targeting embodied emissions, which eventually allows a kind of sanctioning.

The informational feedback effects that emanate from the attempts to govern greenhouse gas emissions and other environmental impacts at multiple levels can also be appreciated as positive nested externalities, which “occur when actions taken within one decision-making unit simultaneously generate ... benefits for other units organized at different scales” (Ostrom 2012, 356). In this sense, diverse polycentrically distributed policies may not only provide information
2. The problem of governing carbon emissions embodied in trade

about relative carbon intensities as a side-effect of their implementation, but they also allow to experiment with novel forms of private and public regulation below the level of nation states or international agreements.

What I provide in this work is an application of the polycentricity framework to the informational domain, which helps us to better understand how the mutual monitoring of actors in climate governance is improved by diverse feedback effects that emanate from a range of different attempts to govern greenhouse gas emissions. I show how the informational component of polycentric climate governance helps to bring novel sanctioning mechanisms into reach, which increase the utility of the common-pool resources framework as it opens up possibilities for working towards a decentralised common property regime.

Policies targeted at the emissions embodied in trade promise to address some of the competitive disadvantages arising from unilateral climate action and thus improve the conditions for more ambitious climate mitigation efforts. The passing and implementation of such policies, however, faces significant challenges in terms of technical and political feasibility. A better understanding of the incremental and indirect steps one could take to improve the feasibility of such policies can help to prepare the ground for their adoption.

Political and technical feasibility are somewhat linked, as it will be easier for organised interests to successfully resist policy proposals that are badly designed or seem unlikely to provide a good relation between costs and benefits. From a policy science perspective interested in identifying potential path-dependencies, not just in the past but also with respect to how these may unfold in the future (Levin et al. 2012), it would now make sense to ask what policy efforts could advance the field in terms of increasing the technical feasibility of including consumption in climate policy. In order to do that it would be important to know what past processes have contributed to this feasibility.

Afionis et al. (2016, 15) suggest that a step-by-step approach to the problem of dealing with consumption-based emissions would enjoy greater political feasibility than a radical change of the current climate policy architecture. The following adopts such a ‘step-by-step’ approach in an epistemic sense: I will trace back the informational conditions for the emergence of what I have identified as some of the most promising instance where actors argue for product standards or procurement criteria that target embodied carbon (see Section 2.7). A focus on standards and procurement criteria is particularly interesting, as progress in this domain may also increase the technical and political feasibility of other
2.6. Carbon disclosure and its critics

In order to better understand how the capacities for the use of EPDs and PCFs as monitoring devices can be strengthened, one needs to locate them in their wider context. If one wishes to look at how information structures the different levels at which environmental and, in particular, climate policy can intervene in economic processes, it is important to understand the range of different scopes at which the monitoring, reporting and verification of emissions occurs. In order to understand the scholarly significance of contextualising carbon disclosure within the debate on consumption-based policies and pointing towards the potential they have to move the atmosphere towards a common property regime, one needs to revisit the arguments of the critics of carbon disclosure.

One can distinguish between disclosure at the level of legal persons, i.e. a firm, a city or state, and products or services, which are produced, acquired and/or consumed by legal persons.

Under the EU ETS and the Californian cap-and-trade system companies that are required to report their emissions per product need to do so at installation level. The product emissions are not publicly associated with any one installation. Only anonymised performance curves of the benchmarking exercises are published (see e.g. California Air Resources Board 2011, 12ff.).

At the next level there is facility-level disclosure. For example, many companies need to provide facility-level data to the European Pollutant Release and Transfer Register (E-PRTR).

Another level up, there is firm-level disclosure. Here one attributes emissions to a company in terms of different scopes, depending on whether these occur directly within the company (Scope 1), are the result of energy purchased (Scope 2) or come in the form of the emissions embodied in the products and services that are used as inputs for the company or that result from the use of its products (Scope 3). The relevance of Scope 3 emissions changes depending on what is considered to be part of its scope and at which point in a value chain one focuses on. There are estimates that for Wal-Mart, the world’s largest retailer, 90% of overall emissions are Scope 3 emissions, which can be allocated to its supply chain of over 120,000 companies (The Economist 2011).

A different kind of disclosure has recently gained currency: the benchmarking
of cities’ (e.g. the C40 city network (Davidson 2015)) or public institutions’ carbon performance. Going beyond operational emissions, cities and public institutions may also want to address the emissions embodied in their buildings or vehicles (for the city level see e.g. Greater London Authority and London Sustainable Development Commission 2013; for a public institution see NHS Sustainable Development Unit, n.d.).

One important distinction in the assessment of the climate impact of products, services or infrastructures is that between embodied and operational emissions (Cabeza et al. 2013). Operational emissions are those that occur during the use phase of a product, building or other kinds of infrastructure. The emissions that result from the different stages of its production, modification and repair can be considered to be embodied in a product or building.

I argue that non-state governance initiatives aimed at increasing the transparency of the environmental impacts embodied in products could help to prepare the ground for an eventual inclusion of embodied emissions into public policy. In contrast, many authors have more cautiously warned against the limitations and pitfalls of privately organised transparency efforts in the environmental realm. This thesis recontextualises their arguments by explicitly putting them into relation to the telos of a potential evolution of the ‘polycentric regime complex’ (Widerberg and Pattberg 2017, 68) towards an inclusion of embodied emissions.

Some authors lament that disclosure may serve to substitute regulation by being part and parcel of a neoliberal or laissez-faire paradigm. For Mason (2008, 10) the underlying normative agenda of

“such voluntary instruments as product eco-labelling schemes and corporate social responsibility initiatives ... [is] ... the scaling back of mandatory environmental regulation ... and the framing of information disclosure options in terms of individual lifestyle choices.”

For Haufler (2010, 56), in a neoliberal global normative environment “transparency is viewed as a way to lightly regulate the private sector, and information disclosure as efficiency-enhancing and necessary for the proper functioning of markets”.

In contrast, the present study shows how different transparency and disclosure initiatives can also, indirectly, help to inform a more muscular consumption-based approach to environmental policy.
2.6. Carbon disclosure and its critics

For some observers more disclosure is not necessarily better. Dingwerth and Eichinger (2010, 2014) point out that people may be overwhelmed by the sheer amount of information that is being disclosed. Information disclosure can even be used to deflect criticism by ‘drowning’ observers in difficult to compare information (Mol 2014, 48; Gupta and Mason 2016, 87). For example, Cho and Roberts (2010, 1) show that “worse environmental performers provide more extensive disclosure”. Disclosure could thus undermine more meaningful improvements in environmental performance.

A range of scholars have cast doubts on the efficacy of carbon disclosure. Wright and Nyberg (2015) criticise the symbolic and environmentally ineffective nature of carbon disclosure. Many of the critiques of carbon disclosure are aimed at a lack of practical commensurability of the information that is being provided. For example, Knox-Hayes and Levy (2011) criticise that the information companies disclose to CDP, a NGO, is not really comparable across firms. Comparing different companies can be complicated as they are composed of bundles of different assets and activities. The official categorisation of membership in a specific class of firm can be misleading.

Furthermore, disclosure at the firm level does not provide the necessary precision for consumers to break this down into purchasing decisions (Fagotto and Graham 2007). Consequently, this lack of product-specific information also prevents public or private incentives from effectively targeting the product level.

Product-level information, however, also has become the object of criticism: Ormond and Goodman (2015, 129) suggest that

“Crucially, product carbon footprinting raises important questions as to whether the carbon reduction strategies these numbers support are the most effective both in terms of cost or carbon reduction ...”

Overall, Ormond and Goodman retain a focus on criticising the assumptions behind tackling climate change via supply chain management and consumer choice, and suggest that

“With the ideology of measurement linked to the ideology of action and this new-found emphasis on those quantifiable and disclosed

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15 In an interview, a representative of an investment company specialised in sustainability-aware investments confirmed that a move away from production may improve the nominal carbon performance of a company, whereas this does not mean that the production itself has become more carbon efficient (Interview in January 2017). There doesn’t seem to be a standardised way of taking such issues into account.
2. The problem of governing carbon emissions embodied in trade

emissions and reductions within a supply chain, we are seemingly sidestepping a more confrontational engagement with the unsustainable consumption practices at the heart of climate change.” (Ormond and Goodman 2015, 129)\textsuperscript{16}

This is symptomatic for an understanding of product carbon footprinting as being solely located in the domain of consumer and business decisions and thus being made the object of a critique of neoliberal practices and imaginaries. 

Cohen and Vandenbergh (2012, 557f.), while striking a more positive note towards PCFs, also imagine them primarily as vehicles for consumer choice. When they discuss leakage, they solely discuss the problem that the introduction of mandatory carbon labelling in some regions may lead to production being relocated to other regions in order to avoid labelling requirements. Their discussion of the compatibility of PCFs with WTO rules also does not address any measures aimed at directly restricting carbon imports, such as tariffs (Cohen and Vandenbergh 2012, 559ff.).

Labels designed to disclose environmental performance inhabit an area where the private and public overlap in complex ways. One the one hand, their private features are pronounced: they can be developed by private actors, certified by other private actors and serve as orientation for the purchasing decisions of private consumers. On the other hand, state actors have also promoted the emergence of new labels and they can increase demand for them by leveraging their power of public procurement. If the lack of information on the emissions embodied in trade stands in the way of implementing measures targeted at embodied emissions, product carbon footprinting has a potential beyond pure consumer-based practices and the private governance of supply chains, namely to enable the inclusion of consumption in public climate policy. This should, ultimately, contribute towards the transformation of the atmosphere from being subjected to open access into common property.

2.7. The emergence of coalitions for embodied emissions policies

Critics have pointed to carbon pricing’s lack of ability to muster industry support for ratcheting it up. For Meckling et al. (2015, 1170)

\textsuperscript{16}See also Ormond (2015).
2.7. The emergence of coalitions for embodied emissions policies

“Progress [on carbon policy] is slow because carbon regulation imposes costs on the powerful few—well-organized energy and energy-intensive manufacturing firms—and provides dispersed benefits to the weak many—the broader public.”

Yet, as long as the threat of carbon leakage is present, it remains challenging to assess whether the difficulty to muster industry support is an attribute of the policy itself or merely of the policy within the context of the spectre of carbon leakage. While there may be valid structural reasons for why carbon pricing fails to generate much industry support, where the spectre of carbon leakage holds sway, one may be ill-equipped to assess whether the lack of industry support is an innate feature of carbon pricing or whether this is due to the specifics of the situation.

Olsen suggests that in order for large organisations to provide public goods under conditions where the action of individual will only have negligible effects but the temptation of free-riding is high, secondary incentives beyond the enjoyment of the public good itself are needed (Olson 1975, 16). Similarly, the secondary incentives some companies and sectors may be able to gain from the adoption of consumption-based policies or border carbon adjustments could help to contribute towards the generation of the global public good of effective climate mitigation.

At each stage of value or supply chains there are specific constellations of relevant actors and differences in the interests they pursue (Henderson et al. 2002; Levy 2008; Falkner 2008, 37ff.). Understanding what novel policies could contribute towards providing some of the informational building blocks for making the inclusion of carbon embodied in trade more technically feasible is already useful by itself. Solely focusing on functional utility may help to provide general policy recommendations. However, anybody wishing to integrate such policies within an ‘orchestrated’ approach, would also want to know more about the differences in the political dynamics that one can expect to be associated with interventions at different points in the value chain. Accordingly, this study also concerns itself with changes in the associated dynamics of political mobilisation.

The above described imperfection of real existing carbon pricing schemes have opened up possibilities for criticising the actual lack of technology neutrality, which can boost demands for alternative consumption-based policies, as they can be portrayed as helping to fix the shortcoming of carbon pricing schemes. In countries such as the UK and Germany there are demands for extending
building performance standards from the pure focus on the use phase to a more comprehensive definition of performance that includes the emissions embodied in the materials used for constructing a building. In California the government has mandated public procurement criteria for specific building materials based on a benchmarking of embodied emissions. This can be seen as a way to direct the benchmarking, which is an element of California’s cap-an-trade systems as much as that of the EU ETS, from a pure application inwards, to the domestic level, outwards – to include imports, too, at least where these are procured by the state. Accordingly, this study examines the case of the construction sector, as it is the most advanced among the major sectors where embodied emissions policies could offer solutions, with vehicles and food being potentially future fields of application.

### 2.8. Discussion and conclusion

A better understanding of the dynamics that lead to the proliferation of PCFs and EPDs could help in devising strategies for improving the conditions for national or international actions on embodied emissions, which may then, eventually help to improve the viability of more ambitious ‘conventional’ production-based climate policies, too. From an Ostromian perspective, these may even be steps towards turning the atmosphere into jointly managed common property.

From this perspective, cues for a strengthening of the institutional conditions for consumption-based policies targeting embodied emissions could be gained by better understanding a yet to be specified ensemble of polycentrally distributed processes, which contribute to the supply and demand of information on the emissions embodied in products.

However, there is no automaticity that such information will lead to the adoption of embodied emissions policies. Therefore, another important question will concern the dynamics leading to the emergence of novel coalitions advocating for embodied emissions policies, and how the alignment of different coalitions can be explained.

Figure 2.2 locates the central arguments of the thesis within Ostrom’s framework of common-pool resource management. Actions to address environmental problems at the point of production generate informational externalities in the form of knowledge about the approximate environmental impacts embodied in products. The availability of this type of information increases the feasibility of
implementing consumption-based approaches in climate policy. The increasing feasibility of these consumption-based policies provides a rationale for certain business actors to unite in novel coalitions to demand the adoption of such approaches. Consumption-based policies can be used as a form of sanction which can limit other actors’ use of the atmosphere for the purposes of selling to export markets. At the same time, consumption-based policies promise to reduce carbon leakage. Both factors can raise the level of ambition when it comes to mitigating greenhouse gas emissions at the point of production. In the Figure, the red dotted lines and text interpret the more concrete stylised pathways within the more abstract parameters of the Ostromian framework outlining the conditions for successful sustainable management of common-pool resources as common property.

In this figure, informational externalities, over time, have feed-forward effects. Eventually, these may feed back to the ambition level of the policies which have helped to generate the informational externalities in the first place. As the original sources of informational externalities (policies and initiatives), the sanctions and the policies, whose ambition levels may be boosted by the availability of sanctions, are polycentrically distributed, one could succinctly term these polycentric feedback effects (see the next chapter on ‘feedback effects’). To what extent such polycentric feedback effects are already or will be present in the future is a matter of empirical verification. The possibility that the overall feedback effects has a chance of manifesting itself in the future, full-circle, is my main argument in favour of the relevance of the following empirical chapters, which each deal with smaller, constituent feed-forward effects.

The idea of polycentricity will be less relevant for the empirical chapters, which deal more with the medium to micro-level. It is more important for framing the overall thesis, and I will come back to it in the discussion. The next chapter proposes a theoretical framework suitable for the analysis of the driving forces that strengthen those elements of the polycentric regime complex that are crucial for addressing embodied emissions.
2. The problem of governing carbon emissions embodied in trade

Figure 2.2: Locating the central thesis arguments within Ostrom’s common-pool resource framework
3. Theoretical framework and research questions

Philosophy recovers itself when it ceases to be a device for dealing with the problems of philosophers and becomes a method, cultivated by philosophers, for dealing with the problems of men.

— John Dewey, The Need for a Recovery of Philosophy

I argue that, by virtue of providing the epistemic basis for novel policies, the drivers for the measurement and disclosure of environmental impacts help to make conditions ripe for the emergence of novel pro-regulatory coalitions in favour of a greater role for embodied emissions in policy-making. Far from being immediately accessible or obvious, it requires considerable theory-building to account for the complex ways in which the underlying, often distant and seemingly unrelated, processes intersect and produce novel outcomes. In the following I will present the theoretical framework which underpins my claims.

This study is located at the intersection between the two problem-driven fields of global environmental governance and environmental policy studies. Whereas global environmental governance has firm roots in political science and international relations theory (O’Neill et al. 2013, 442), environmental policy studies have a strong economic bent.

For analysing my case, I draw on the different institutionalisms in political science and economics in a problem-driven manner. Whereas concepts such as transaction costs and spillover effects tend to be associated with economic or rational choice institutionalism, the concepts of layering and conversion grew out of historical institutionalism. Other considerations are more closely related to sociological concerns. The semiotic aspects of institutional change also play
3. Theoretical framework and research questions

a role, which may be bracketed under discursive institutionalism.

While I assemble the theoretical framework from extant elements, sometimes more and sometimes less well established, my genuine contribution consists in combining the different elements in order to construct a representation of the informational and institutional sources for the governance of embodied emissions, and the political implications flowing from it, in a way that both allows to account for isolated micro-effects as well as for more complex, emergent, meso- and macro-level effects.

The following section discusses different approaches towards the valuation of governance initiatives and emphasises the challenge of complex interaction effects within the global climate change regime complex. Section 3.2 lines out a framework for the analysis of ‘informational institutions’ as elements of regime complexes. Section 3.3 introduces the key concept of commensurability. Section 3.4 considers how the shift from production-based disclosure to the disclosure of the environmental impacts embodied in products may affect coalition-building and how shifts in the locus of politics along value chains may be accompanied by changes in action situations along the pluralist-corporatist continuum. Section 3.5 introduces the economic institutionalist concepts of transaction costs, spillover effects and complementarities and how they are put to use in this thesis. The chapter concludes with the introduction of research questions and corresponding propositions.

3.1. Valuing climate change governance initiatives

Given that some of the world’s most renowned climate policy expert deem a product-specific levelling of the carbon price at the border so technically challenging that it stands in the way of adopting it, and officials of the European Commission also deem the inclusion of consumption into the ETS as technically too complex and politically hardly feasible, it seems a worthwhile challenge to advance an in-depth examination of the currently already existing elements, which may eventually form a polycentric regime complex that permits either such a cross-border levelling of carbon prices or alternative measures helping to close the consumption gap in climate policy.

For Bäckstrand and Lövbrand (2016, 2), the failure of the 2009 UN climate conference in Copenhagen to successfully replace the Kyoto Protocol with a comprehensive and legally binding climate treaty, and the adoption of the Copen-
3.1. Valuing climate change governance initiatives

Hagen Accord with its system of voluntary carbon reduction pledges instead of the Kyoto Protocol’s binding emission targets and timetables, has marked the rise of a more fragmented and decentralised climate policy architecture. Today, there is a plethora of transnational climate change governance (TCCG) initiatives, often connected to each other “by actors involved in more than one initiative, by mutual recognition of each other’s rules and practices, by mimicry, by operating in the same sort of policy space, by funding arrangements or by functional or synergistic interactions” (Bulkeley et al. 2014, 176). Scholars have sought to theorise the increasing role for public–private collaboration and climate action beyond the state as variously: a transnational regime complex (Abbott 2012, 2014), global climate change complex (Bulkeley et al. 2014, 176), orchestration (Hale and Roger 2014), or polycentrism (E. Ostrom 2010c; Jordan et al. 2015), to name only some of the more prominent conceptualisations (for an overview see Bäckstrand and Lövbrand 2016, 2).

The global climate change complex can be seen as a polycentric system “characterized by multiple governing authorities at differing scales rather than a monocentric unit” (E. Ostrom 2010c, 552). Governance is working through different modes such as public, private and via networks, and one can observe frequent interactions between public policy and transnational governance (Jordan et al. 2015, 980). In the following, when I refer to the global regime complex on climate change, I refer to a polycentric regime complex consisting of both the intergovernmental and transnational spheres (as in Widerberg and Pattberg 2017, 68).

The measurement and disclosure of the carbon emissions associated with economic processes is a key element of the polycentric climate change regime complex. Abbott’s (2012) conception of a transnational regime complex governing climate change emphasises the institutional diversity in this domain. Green (2013b, 6) shows how private actors have acquired authority in this field by defining “actual rules, standards, guidelines, or practices”. Authority in this sense is not zero-sum, where more authority for one actor means necessarily less authority for another; in a polycentric world, actors may compete with each other (Jordan et al. 2015, 980) but they may also draw on each others’ work, thus re-enforcing each other (Jessica Green 2013b, 9). However these actors interact, it is important to be attentive to the co-evolution of the private and the public sectors (on co-evolution see Bleischwitz, Andersen, and Latsch 2005, 170).
3. Theoretical framework and research questions

Given these complexities, it can be difficult to assess which interventions have been successful, how to gauge success and, consequently, which actions to promote in the future. Forward-oriented strategies aimed at improving the effectiveness of the climate change regime need to untangle these complexities and come up with well-reasoned proposals for strengthening crucial regime elements.

For illustrative purposes, one could oversimplify the positions of governance scholars into the camps of those who subscribe to a perspective of the linear aggregation of mitigation actions and those who emphasise their complex interactions. This has become particularly pronounced in the assessment of the contribution of climate governance initiatives. For example, Widerberg and Pattberg analyse a number of initiatives recognised by the UN Framework Convention on Climate Change (UNFCCC) as Cooperative Initiatives, which are, according to the UNFCCC (n.d.), “[c]ooperative efforts undertaken at different levels [which] contribute to catalysing national action and enhancing the ambition at the national level”. Amongst these are the G20 and the International Renewable Energy Agency (Widerberg and Pattberg 2015, 49). While the category of International Cooperative Initiatives (ICIs) remains ambiguous, which is acknowledged by Widerberg and Pattberg (2015, 53), they nevertheless come up with a number of key recommendations to improve the effectiveness of ICIs. Amongst these is the recommendation that ICIs “should set quantifiable targets expressed in terms of GHG reductions” (Widerberg and Pattberg 2015, 53).

A UNEP (2015, vi) report also suggests that:

“Quantifying the emission reduction contributions these initiatives can (or are likely to) make is now critically important to understanding their overall impact on international climate mitigation efforts” (also cited in Van der Ven, Bernstein, and Hoffmann 2017, 4).

Similarly, Bakhtiari (2018, 656) suggests that “from the point of view of climate change mitigation, evaluating the merits of the actions [by non-state actors] entails being able to measure the size of the additional emissions reductions that they bring about”.

Other suggestions for evaluation frameworks emphasise the need for clearly defined outputs (as reviewed by Van der Ven, Bernstein, and Hoffmann 2017, 5). For example, Chan et al. (2018, 29) conducted a large-scale comparative assessment of “whether climate actions produce outputs that are consistent with their main functions”, where they derived the functions from the stated aims of
3.1. Valuing climate change governance initiatives

the actions. They freely admit that “[o]utputs do not reveal whether problem-solving has occurred, nor do they necessarily result in desired changes” (Chan et al. 2018, 28). While evaluating climate actions in terms of how their outcomes match their stated aims is a valuable exercise, such an approach is necessarily limited to intended and quantifiable actions.

Van der Ven et al. (2017, 5) insist that the sole reliance on directly measurable outcomes fails to address the need to disrupt carbon lock-in (Unruh 2000; Seto et al. 2016) by contributing to the wholesale transformation of the institutions governing economic, social, technological, and governance processes. Accordingly, they seek to address how governance initiatives may catalyse change across levels and domains.

Bernstein and Cashore (2012, 586) advocate for a shift from ‘effectiveness’ to ‘influence’ in the study of global environmental governance in order to account for the fact that global environmental issues are not governed by single-issue regimes based on comprehensive multilateral treaties but by “an array of mechanisms that include legal, non-legal, governmental and non-governmental arrangements.” The shift from effectiveness to influence leads towards a focus on effects.

The existing literature on environmental disclosure has largely focussed on evaluating its effectiveness, i.e. whether it succeeds in what people claim should be its benefits, which could be labelled intended effects (Hamilton 2005; Fung, Graham, and Weil 2007; Gupta 2008, 2010; Mason 2008; Florini 2010; Kraft, Stephan, and Abel 2011; Mitchell 2011; Kosack and Fung 2014). When we learn from the past in order to guide our actions, we should not evaluate others’ actions solely in terms of their effectiveness but in terms of their effects. Otherwise, indirect – initially unintended – effects may escape our attention.

Likewise, the informational side-benefits of environmental policies have received scant attention. For example, in their paper on “Instrument Choice in Environmental Policy”, Goulder and Parry (2008, 152) list a range of criteria, which economists use for evaluating the choice of environmental policy instruments:

- economic efficiency and cost-effectiveness,
- distribution of benefits or costs,

\[1\] This shift from effectiveness to influence echoes Foucault’s (2009, 162f.) shift from intention to effects, i.e. a shift away from a formal analysis of institutions. This mirrors the shift in the USA from ‘old’ to ‘new’ institutionalism (Steinmo, Thelen, and Longstreth 1992, 6).
3. Theoretical framework and research questions

- ability to address uncertainties, and
- political feasibility.

The criterion of whether environmental policies generate information is not present. Goulder and Parry do acknowledge the existence of information disclosure programs, such as the Toxic Release Inventory, but seek to focus on mandatory regulatory policies. Interestingly, the informational side-effects of policies, whose stated aim is not the disclosure of information, are not subject of the review.

In contrast, Coggan et al. (2010, 1783) suggest that “transaction costs experienced in activities such as information collection and information provision in initial policy stages may reduce the policy transaction costs experienced in ongoing policy operation in the future.” By introducing an intertemporal perspective on policy design, these authors are well able to appreciate the relation between informational demands and the informational effects of policies.

3.2. Informational institutions

For Mol (2014, 41), in order to understand the logic and transformative power of transparency one needs to conceptualise it from the vantage point of informational governance or regulation by information. This requires a focus on the interplay between informational processes, resources, and politics.

Increasingly, environmental struggles and controversies are located on the terrain of the informational, what may be called the ‘information scape’ (Mol 2014, 43). Mol (ibid.) points out that

“Information and knowledge are becoming important resources in environmental politics, the sites and spaces of environmental controversy are relocating to information, and the motivations and sources for changing unsustainable behavior are increasingly informational.”

It is important to analyse how various mechanisms interact at different levels. Mirroring the shift to influence or effects, Eberlein et al. (2014, 2/11) emphasise the importance to pay systematic attention to the interactions among governance actors and institutions in order to fully understand the role of information

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2 As argued below, I would suggest to call these costs, which they term here ‘transaction costs’, ‘information and monitoring costs’ instead.
production. Once one conceptualises information and knowledge as resources upon which politics can draw, it is only one step further to consider how some institutions produce informational or knowledge resources upon which other institutions can draw in a process of informational-institutional layering (more on ‘layering’ below). Such informational-institutional layering may then interact with forms of institutional or discursive layering.

Mol (2014, 45f.) exhorts us to not lose sight how individual transparency mechanisms in environmental governance are “‘structurally’ embedded in wider social developments and trends”. The following account will alternate such a wider lens with in-depth examinations of micro-mechanisms in order to trace the institutional conditions for and the informational aspects of the contestation over advocacy for a greater role for embodied emissions accounting in environmental politics.

In order to better understand the rise of product level carbon life cycle information and to explain its causes and pre-conditions, I suggest that the most appropriate framework would be a type of historical institutionalism with a focus on the conditions for information production: an informational institutionalism. Drawing on North (1991), Ge and Brewster (2016, 74) define informational institutions as

“... the informal and formal social arrangements governing the flows of information to influence behaviour.”

This definition might be taken to suggest a clear-cut distinction between informational institutions and other types of institutions. How do we tell whether an institution is of an informational character or not? How would such a heuristic look like? Ge and Brewster (2016, 75) make clear that “developments in informational institutions are inextricably intertwined with developments in social institutions”. Due to this inextricability I refrain from presenting a kind of heuristic by which one could tell an informational institutions from its ‘other’. Instead, in a pragmatic way, I argue that an informational institutionalism needs to be attentive to the role of informational aspects in the evolution and co-evolution of institutions and organisations. Whether and in what ways the governance of informational flows has been decisive then becomes an empirical question rather than one to be answered prior to an investigation.

An informational institutionalism would be the adequate perspective for tracing the use and generation of information across actors and scales. Without
claiming the foundation of a novel theoretical framework, I solely suggest informational institutionalism here as a short hand for the application of institutionalist approaches in a way that explicitly focuses on the informational contributions and requirements of different institutional developments.

There is an inherent temporal dimension to climate politics. Time is running out, or, at least, time matters. In so far, one cannot rely on framing research questions in the way of whether \( x \) is sufficient (or necessary) to bring about \( y \), but one also needs to ask, for example, whether an increase in \( x \) can help to speed up the scaling up of \( y \) within a relatively short period of time. The importance of time is among the reasons why the notion of catalytic effects, which generate and accelerate decarbonization pathways (Bernstein and Hoffmann 2018, 194), has risen to the fore.

Whereas the synchronic mode of analysis concerns itself with analysing the interactions of the already given elements within a social system, the diachronic mode looks at structural change, asking how the current order came about and how it may be changed (on diachronic and synchronic modes of analysis see Cox and Schechter 2002, xii / 31/150f.). The ‘market’ is the archetype of a synchronic concept (Cox and Schechter 2002, 180), modelled as tending towards equilibrium at any given time. In contrast, ‘industry’ is oriented towards the future and thus has a forward-looking bent (Boltanski and Thévenot 2006; Blok 2013, 496). Where one analyses social facts as something produced, and considers the consequences of this production, one enters the diachronic mode of analysis (Cox and Schechter 2002, 31). Whereas other institutionalisms could be satisfied with solely focussing on the present, although they are by no means constrained to that, historical institutionalism’s ‘unique selling proposition’ is the diachronic mode of analysis. While it does not excel at the synchronic analysis of ‘markets’, it can contribute towards a better understanding of the emergence and transformation of markets.\(^3\)

We need concepts that help us to explain change in a complex multi-actor environment. In the following I introduce four typologies of institutional change. The typologies of institutional change concern the a) modes of institutional change and the conditions that facilitate them, the different ways of how interventions can become b) scaled up and c) entrenched, and d) how environmental

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\(^3\)Similarly, here I employ what may be termed staple concepts of rational choice institutionalism, or of the ‘new’ institutionalism in economics, as well as what may be deemed concerns of discursive institutionalism for the theorisation of historical change.
3.2. Informational institutions

Politics can become rescaled.

Mahoney and Thelen (2009) propose four modal types of institutional change: displacement, layering, drift, and conversion. Displacement is a process where new rules replace old ones. The process can be rapid or slow-moving. There might be an immediate replacement or a transition period in which both sets of rules compete with each other. The process may also get stuck in a partial replacement, with different, competing rather than complementary, rule sets in place (Mahoney and Thelen 2009, 16).

Layering is the addition of new rules to a set of existing ones, thereby changing how the original rule set structures behaviour (Mahoney and Thelen 2009, 16). Rather than making entirely new institutions or rules, layering involves amending, revising or adding to existing ones. Layering can substantially alter the logic of the institution or the trajectory of its reproduction. Over time, and in conjunction, small additions and revisions can accumulate and substantially change the trajectory of the institution (Mahoney and Thelen 2009, 16f.).

Now, the concept of layering invites to discussions about its scope. Are we only talking about adding new instruments on top of existing ones or does the concept also encompass the addition of new actors? I use the concept in a way that comprises both the addition of new actors and new instruments, a tendency in the literature whose beginning Van der Heijden (2011, 14f.) dates with Thelen’s development of the concept. Ergo, when it comes to information-generating institutions, a different use of information than originally intended, in another context, can constitute such an instance of layering; regardless of whether we observe it between or within institutions or organisations. Such a different use is likely to occur on the basis of relating one kind of information to another kind of information.

Drift denotes a process where the rules stay formally the same, while, due to changing external conditions, their impact changes. When actors do not adapt to such changed circumstances, their very inaction can lead to a change in the impact of these institution (Mahoney and Thelen 2009, 16ff.).

Conversion is a strategic redeployment of existing rules towards new aims (Mahoney and Thelen 2009, 16f.). Whereas institutions may have been forged at a particular historical juncture, as the outcome of a specific constellation of interests and conflicts, their redirection towards new ends can be described as an instance of institutional conversion (Thelen 2002, 103).

\footnote{Based on Streeck and Thelen (2005).}
This leads me to the following Proposition: Energy efficiency policy has indirectly helped to improve the informational basis for addressing emissions embodied in building materials, as it has increased the relative importance of embodied emissions and thus resulted in a drift in the impacts of energy efficiency institutions themselves, which has opened them up to demands for institutional conversion into carbon efficiency institutions, or, at least, has created demand for other institutional layers, which may take embodied carbon into account (see Chapter 6).

Intra-institutional layering activity may not always be neatly distinct from conversion. From a certain degree of intra-institutional layering on, the overall functions and purposes may change.

What factors decide over which of these modes of institutional change is more likely to occur? Mahoney and Thelen suggest two main dimensions, whose combined effects are likely to produce different outcomes: differences in veto possibilities and the extent of discretion in institutional enforcement and interpretation. While displacement, layering, drift and conversion are either about the change of rules or their meaning in relation to the external environment, veto points and the degree of discretion are about the intra-institutional conditions for such change to occur.

The number of institutional veto points or the strength of veto players determines whether there are strong or weak veto possibilities. Where there are actors who have access to the means to block change, veto possibilities are high (on veto player theory Mahoney and Thelen refer to Tsebelis 2002). Direct displacement is unlikely to occur where there are strong veto possibilities. Wholesale conversion will also be a challenge in such a context. In contrast, drift and layering do not require overcoming veto players and are thus more likely modes of change.

Discretion in institutional enforcement and interpretation concerns the degree to which actors in institutions have leeway over mission aims or the interpretation of the rules they are supposed to follow. Mahoney and Thelen suggest that with only little discretion in enforcement and interpretation, drift and conversion are less likely to occur. In contrast, in processes of layering and displacement new rules are not fitted into the shape of existing institutions but they complement, compete with or replace them.

Beyond the differences in veto possibilities and discretion, I argue that the degree of commensurability of actions that are ought to be regulated should also
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affect which mode of institutional change is more likely to occur. When one wants to explain the ‘evolution’ of the regime complex on climate change, one wants to explain processes of institutional change. A high degree of commensurability of the central unit of account, around which the climate regime revolves, should endow two modes of institutional change with particular powers: *layering* and *conversion*. Both open up possibilities for political pressure to be exerted and alliances’ demands to converge around. I argue that the potential of these modes of institutional change is stronger in the domain of climate politics than in other domains because of the high degree of commensurability that can be constructed between the different activities contributing to anthropogenic climate change. This is in contrast to other domains, such as chemical pollution, biodiversity, fisheries and water, where the relation between cause and effect is more regionally anchored.

Actors also actively and purposefully engage in the construction of institutions instead of being solely constrained by them (Schmidt 2008). Thus, layering activity should not only be conceptualised as something where only the top layer is consciously applied but one also needs to take into consideration the possibility for layering activity that can be, at least partially, motivated by the expectation that the layer applied in a first step may be drawn upon by another layer in a second step, and may result in the potential conversion of institutions down the line. Such a consideration introduces anticipation and speculation as drivers for actors’ activity (Beckert 2013b, 2013a). While there is the temptation to look at the evolution of institutions as akin to that of the animal kingdom, where there are only consequences arising from external constraints without any intentional shaping of evolutionary outcomes, an evolutionary lens on institutions would need to take into account conscious efforts by actors to steer institutional developments into certain directions. For example, Section 7.1 shows how already in the 1990s environmental policy experts suggested that LCA would be an important building block for environmentally aware public procurement and the greening of markets. Two decades later, the institutionalisation of LCA and EPDs could then be layered onto by Californian public procurement (see Chapter 5 and Chapter 6).

In order to make the climate-relevant properties of different materials commensurable, different metrics need to be layered onto each other in order to make different qualities comparable. For example, sustainable sourcing certifications and assessments of the carbon content of timber are requirements for
making it commensurable with steel and cement in the buildings sector.

The successful construction of institutions requires the mobilisation of mutually reinforcing discursive, material and organisational elements (Knox-Hayes and Levy 2011, 3f.). The same set of elements needs to be taken into account for explaining changing political dynamics. Focussing on the politics of decarbonisation in general and the contributions of non-state and sub-national actors in particular, Bernstein and Hoffmann (2015, 5, 2018, 191) and Van der Ven et al. (2017, 5) suggest three mechanisms by which interventions potentially alter extant political dynamics:

1. They catalyse normative change (discursive)
2. They build capacities for acting in new or different ways (see also Jordan et al. 2015, 978) (material and organisational)
3. They change the dynamics of coalition building (organisational)

Bernstein and Hoffmann (2015, 21) particularly highlight two mechanism of norm change, processes where expectations about appropriate behaviour shift: First: proposals of and advocacy for new ways of looking at the world. For example, CDP has introduced the notion that carbon disclosure is an important part of Corporate Social Responsibility (CSR) (on CDP see Section 9.4.1). Second: actual changes in everyday practices. For example, once carbon disclosure is adopted, carbon accounting becomes part of administrative routines. Attributing importance to the mechanism of normalisation assumes that “agents are habit driven and concerned with integrating themselves into a given social order, its norms and rules” (Bulkeley et al. 2014, 41). Such norms and rules can then be usefully subjected to being analysed as more or less formal institutions (Thelen 1999, 382). Chapter 6 argues that the prior adoption of sustainable building norms provided a normative basis for actors to demand the inclusion of the criterion of embodied emissions into building standards.

Capacity building can operate via material, institutional and cognitive pathways (Bernstein and Hoffmann 2018, 122). Capacities can most obviously be strengthened by committing financial resources. For example, the UK government has supported the Carbon Trust, and its carbon foot-printing work, with material financial resources.\(^5\)

\(^5\)Note that this came in addition to its support for carbon trading, i.e. the financialisation of carbon policy, and its support for the CDP (Hale and Roger 2014, 77).
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Institutional capacity-building enhances the ability to make decisions and implement programmes. For example, the Greenhouse Gas Protocol has created standards for the accounting of greenhouse gases, which has facilitated the comparability of greenhouse gas emissions among firms as well as among products. This has provided for a common language in which to talk about emissions, such as the distinction between different emissions scopes.

‘Capacity-building’ may evoke the idea of an intentionality behind it. Yet, from an informational perspective it is fruitful to also take into account instances of capacity-building that may only be the side effects of actions that have been pursued with intentions not directly related to the capacities which they end up strengthening. In this sense, capacity-building can already occur by the provision of data which may not be very useful by itself except for the purposes of triangulation.

The concept of *triangulation* is useful in order to better understand the conditions for the emergence of an informational landscape that permits the assessment of the environmental impacts embodied in products. The term *triangulation* is a metaphor borrowed from navigational and land surveying techniques that use the convergence of measurements taken from at least two distinct points to determine a single point in space (Rothbauer 2008, 892). Where those who disclose information on the environmental impacts embodied in the products they sell have incentives to cheat, the possibility to triangulate different data sources should help to better detect cheating, at least where this results in suspiciously low values for the assessment of environmental impacts. In one sense, some of the chapters that follow deal with different such data sources. In another sense, they do deal with a highly interconnected phenomenon, as these data sources can be triangulated and the credibility of each of these different sources may thus be interconnected. Seemingly unrelated actions may help to ‘build capacity’ by generating data which allows experts to triangulate and improve the basis for their assessments.

*Cognitive* capacity-building enhances peoples ability to perceive problems and to understand how to solve them. For example, the UK Institution of Civil Engineers has briefed its members on the current ways of measuring embodied energy and carbon (McAlinden 2015). Chapter 8, Chapter 9, Chapter 10, and Chapter 11 argue that initiatives which had the effect of improving capacities for knowing more about the environmental impacts of production activities have had spillover effects, which then helped to also improve capacities for knowing
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more about the environmental impacts of products over their life cycles.

This study argues that the emergence of novel coalitions, as observed in Chapter 5, has benefited from the indirect effects of a range of other initiatives, which have helped to provide the conditions for making carbon emissions embodied in products commensurable.

These mechanisms of change in norms, capacities and coalitions may lead to the upscaling and entrenchment of interventions in the targeted systems as well as in other, linked, sub-systems. The effects on these systems then lead to three possible trajectories: “unintentional reinforcement of carbon lock-in; improvements or efficiency gains in carbonized systems; or transformational decarbonization” (Bernstein and Hoffmann 2018, 191). Analysing these pathways can inform the generation of hypotheses on “how changes in sub-systems can catalyze, cumulate, or possibly tip the balance of larger systems of carbon lock-in towards decarbonization” (Bernstein and Hoffmann 2015, 5).

A fuller commensuration process at the level of consumption would have the potential to lead to more transformational change as it pitted products and services against each other with respect to their life cycle emissions. From here springs the need to adopt a holistic perspective that seeks to examine the linkages between different sub-systems, e.g. buildings, heavy industry, corporate accounting, LCA databases, and climate policy – and how their interactions have historically improved the conditions for carbon commensurability to succeed.

Arguably, free allocation in emissions trading systems has resulted at best in mere improvement or efficiency gains in carbonised systems (see Chapter 2). One can assume the same of energy efficiency policy. However, in the remainder of this study I will show how some policies, which purely target efficiency improvements or may seem to lack effectiveness otherwise, can have indirect effects, which improve the conditions for commensurability and, thus, bear the potential to contribute towards more transformational trajectories.

Drawing on Bernstein and Hoffman (2015) and looking in particular on decarbonisation interventions by non-state and sub-national actors Van der Ven et al. (2017) focus on the two system effects of scaling and entrenchment.

In processes of scaling interventions can become more impactful over time. Van der Ven et al. (2017) distinguish between:

- simple scaling,
- self-organized scaling,
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- cross-over scaling, and
- modular scaling.

Simple scaling is a process where an initiative starts out small and then grows. Here, the initiative may gain more members or resources, it may expand its geographic scope or with regard to the range of activities it undertakes (Bernstein and Hoffmann 2015, 26). For example, the numbers of companies reporting their carbon emissions to CDP, a charitable organisation, has increased and the organisation has expanded its reporting requests from firm-level to value chain emissions. So has the number of EPDs for construction products on the market (Anderson 2018).

The concepts of self-organised scaling and cross-over scaling overlap with the concept of layering: some interventions open up new possibilities for further interventions, where one intervention can draw on the output of a prior intervention. This is a kind of clustering effect, which facilitates self-organised scaling. Activities can be complementary to each other and jointly they may engender increasing returns to new or extant interventions (on increasing returns see also Pierson 2000). Recent decades have seen a spectacular growth of private transnational regulatory organisations (PTROs). An important factor in the growth of the number of PTROs is “their ability to locate and form complementary relationships” (Abbott, Green, and Keohane 2013, 264), either with other PTROs or with state-led initiatives. The voluntary carbon market is an example of such self-organised scaling: once carbon offset producers emerged, additional actors could offer complementary interventions, such as carbon offset and carbon credit registries, carbon standards, and carbon accounting (Bernstein and Hoffmann 2015, 26f.). Relevant for this study, green buildings councils incorporated EPDs in their building certification systems by offering ‘points’ for their use, thus seeking to steer the market by drawing on the output of a prior intervention (see Chapter 6).

Cross-over scaling occurs when non-state intervention affects conventional public policy (Van der Ven, Bernstein, and Hoffmann 2017, 9). For example, the state of California incorporated private sector EPDs into its procurement criteria, whose diffusion had been stimulated by the reward green building councils were offering for them (see Chapter 6).

Modular scaling denotes the conscious borrowing of ideas that were initially developed in another intervention. A classic example from the area of public
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Policy would be processes of policy diffusion. An example of modular scaling from the area of non-state governance would be the emergence of different green building organisations and certification schemes around the world, at least where these are not part of the same franchise (see Table ??).6

The concept of self-organised scaling may evoke the image of an autonomous development, where societal actors spontaneously enter functional relations. However, often powerful actors help steer such developments. We can grasp this in terms of ‘orchestration’. Abbot (2014, 27) describes ‘orchestration as follows’:

“In orchestration, an entrepreneur with significant authority, legitimacy and/or resources ... acts as ‘orchestrator’, enlisting the cooperation of other organizations within its own cohort and at other levels of governance, and steering their structure, activities and relationships. Lacking hierarchical authority, the orchestrator utilizes incentives and soft tools of influence rather than mandatory controls. Orchestration is the most feasible strategy in the polycentric setting of transnational climate governance.”

With many actors involved, the role of the orchestrator may swap swiftly, or there may not be a single focal point of orchestration. While Hale and Roger (2014, 60f.) from the outset assume the orchestrators to be governments or international organisations, Abbott (2014, 26) also sees a potential for non-state actors to take up that role. Looking at the longer term and focussing more on structures, the point of identifying who the orchestrator is may be moot. Here the concept of orchestration gains its explanatory, and ‘real world’, power by combining it with the concept of institutional layering. At the same time, the conceptualisation I propose here does not lead to a post-modern or pluralist ‘everything goes’ account, that merely points to the multiplicity of governance actors and arrangements in the polycentric world of trans- and international climate governance. On the contrary, my aim is to show how such, sometimes more and sometimes less orchestrated, layering has palpable effects in terms of shifting epistemic power and the locus of politics along value chains.

Processes of entrenchment generate “substantive effects that are durable and difficult to reverse” (Van der Ven, Bernstein, and Hoffmann 2017, 8). Bern-

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*With DiMaggio and Powell (1983, 151f.), this can also be called mimetic isomorphism.*
stein and Hoffmann (2015, 28) distinguish between “four primary processes of entrenchment”:

1. **Lock-in** is defined by the immediate durability or stickiness of an intervention,
2. **self-reinforcement** is marked by rising costs of reversing an intervention,
3. **increasing returns** are characterised by increasing benefits to the targets of an intervention, and
4. **positive feedbacks** occur when initially untargeted populations join in and thus make the choice for the initial target population even more attractive.

The typology of the different modes of institutional change helps to explain under what conditions one is more likely to see a change in the effects of old institutions, their displacement, their conversion or the birth of entirely new institutions. This also helps to explain the drivers of private or subnational action to emerge as a complement to government action. The typology of scaling helps to theorise about the different ways interventions can generate stronger effects over time, beyond their initial possibilities, and the typology of entrenchment helps to understand the conditions for an intervention to become durable and provide a basis for upscaling.

We can find a conceptual overlap between Van der Ven et al.’s concept of simple scaling and Andonova and Mitchell’s (2010, 257) concept of rescaling, defined as “a shift in the locus, agency, and scope of global environmental politics and governance across scales, with scales understood as the various ecological and social levels at which environmental problems and societal efforts to address them occur”. Now, a direct conceptual comparison may be problematic as Van der Ven et al. focus on non-state initiatives and Andonova and Mitchell on the wider domain of environmental politics and governance. Be it as it may, what is of interest here is that whereas the first two dimensions of Andonova and Mitchell’s rescaling concept match simple scaling quite well, the third dimension adds something fairly important: Andonova and Mitchell (2010, 258) distinguish between vertical – a moving along the continuum between inter alia individuals at the lowest level, over NGOs, nation states, INGOs, to intergovernmental organisation – and horizontal rescaling – on the continuum between single and many actors. To this typology they add a third dimension, which is
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the rescaling across issue areas. Here they give the examples of the connection of environmental to developmental politics, and the links between environment and trade, on the one hand, and environment and security, on the other hand (2010, 265ff.).

This third dimension is crucial for the analysis undertaken here because the associated concept can also be applied to climate politics proper and the dynamics by which it becomes disembedded and re-embedded in wider environmental politics. Specifically, where PCFs are ‘packaged’ within more encompassing EPDs, the conditions for the gathering and measuring of these wider environmental impacts also affect the costs for creating PCFs.

3.3. Commensuration processes

How can one subsume the diversity of far-flung economic processes that are involved in the production of goods and services under the heading of ‘embodied emissions’? How can one make these comparable with other relevant emissions?

Commensuration can be defined as “the transformation of different qualities into a common metric” or “the expression or measurement of characteristics normally represented by different units according to a common metric” (Espeland and Stevens 1998, 314f.). Commensuration, however incomplete and beset with uncertainties, is crucial for deciding on a course of action amidst complex sub-system interactions. Carbon has become a central unit of account for the evaluation of production and consumption practices in climate politics (Kolk, Levy, and Pinkse 2008). It is the unit of account by which different processes are made commensurable across time and space.

Processes of commensuration affect the drawing of boundaries between issues. What do shoes and apples share in common? They are both commodities, traded on the market, purchasable for money. What do timber and plastic have in common? They are both commodities, both building materials. Yet, due to processes of commensuration they can also be assigned a carbon footprint, so as to become interchangeable in carbon terms. As carbon emissions are not locally bound and wherever they are emitted contribute to global climate change, they lend themselves to the construction of equivalence between substantially different carbon emitting acts. However, the information needed to construct such equivalences is initially often absent or only found in fragmented form, dispersed among multiple sources.
3.3. Commensuration processes

For carbon commensurability to be constructed, information on the carbon emissions associated with products and processes need to be created and brought into a common, standardised format. Institutions that facilitate information disclosure and standardisation are thus pivotal for the emergence, stabilisation and extension of commensurability.

This provides another way to arrive at the proposition that energy efficiency policy has indirectly helped to improve the informational basis for addressing emissions embodied in building materials, by making operational and embodied emissions commensurable (see Chapter 6).

It can be argued that the attempts to create carbon markets have succeeded in socially constructing carbon as a commodity with a price attached (Levin et al. 2012, 147). As Polanyi (1992, 43) writes: “What nature made distinct, the market makes homogenous”.

Yet, the results of this construction are not necessarily limited to carbon markets proper but can also be used to endow products with carbon attributes, which then allows to subject them to policies strictly focused on these attributes.

One needs to distinguish between potential and practical, or actual, commensurability. The first is based on the plausibility of claims, the second on the practical means to render processes or materials commensurable.

Climate policy concerns itself with the shaping of the future. As different socio-technical pathways are calculated and advocated, assumptions of future emissions and their socio-physical impacts introduce a dynamic temporal quality to commensuration processes. These temporal assumptions are composed of multiple sub-system pathways. In the struggles over different development pathways actors bring different approaches towards the commensuration of entities and processes to bear.

The notion that climate policy ought to be technology-neutral is closely related to attempts at making different acts commensurable with regard to their effects on the climate. Only policies that draw on such commensuration, for example by pricing carbon, can claim to go beyond privileging one technology over another in a way that is neutral towards their more arbitrary characteristics and that entirely focuses on the outcome variable to be addressed: carbon emissions.

Commensuration processes can interact with the three mechanism by which interventional potentially alter extant political dynamics, as laid out by Bernstein and Hoffmann (2015, p. 15): once normative change has been achieved,
actors can dock onto the newly established norms and legitimate further reform by reference to these norms, showing that the aims of earlier initiatives are related to proposed reforms via common metrics, and thus assert commensurability. Actors can then demand more policies, or their extension, by arguing that the normative aims by reference to which the policies are justified, would be better, or more completely, served by either extending a policy, by instances of institutional layering, or refocussing it, in the form of institutional conversion.

The establishment of capacities, which enable actors to achieve some degree of carbon commensurability, can be potentially drawn upon by other actors to further extend these capacities. For example, the establishment of standards for measuring the energy efficiency of a building is a necessary precondition for measuring whole-life carbon emissions, which consider both use phase as well as embodied emissions in a standardised way.

Furthermore, the technical capacities for commensuration can affect how much commensuration becomes normalised as part of explicit considerations or in everyday practices. Espeland and Stevens (1998, 329) suggest that “[i]nstances of commensuration vary by how institutionalized they are, that is, they vary in how automatically commensuration gets done and in how natural the process seems to involved parties.” Here we see strong links between the processes of capacity-building and normalisation.

The next section deals with the political effects of achieving carbon commensurability at the product level.

### 3.4. Rescoping and its feed-forward effects on coalition-building

While the concept of rescaling helps us to grasp horizontal, vertical and issue shifts, it still fails to adequately describe a transformation at the core of this work: the shift from place-based to placeless systems of disclosure and regulation, from point to flow (Mol 2014, 52). As I will show in the empirical part, in order for this to occur successfully, at least in the case I am looking at, a process of repeated layering has been necessary in order to transmit and assemble the information representing the value or commodity chain culminating in a product (on value and commodity chains as well as the idea of production networks see Gereffi 1994; Henderson et al. 2002; Ponte and Gibbon 2005; Levy 2008; Ponte and Sturgeon 2014). To distinguish between rescaling and the transformation
3.4. Rescoping and its feed-forward effects on coalition-building

from place-based to placeless systems, I will refer to the latter as *rescoping*.

As I will show in the empirical part, interventions aimed at regulating the level of the firm or industrial facility have supported the emergence of institutions and bodies of knowledge, which then helped to target the carbon footprint of products. This, in turn, can lead to reconfigurations of the dynamics of coalition-building.

The ‘re-scoping’ of climate politics can be affected by a rescaling between a wider environmental lens and a more specific focus on carbon emissions. However, the shifting towards consumption-based approaches is likely to be particularly impactful in the domain of climate politics, due to the high degree of commensurability attributed to ‘carbon’.

One can distinguish between policy feed-forward effects and feedback effects. The consequences of a policy can be deemed feed-forward effects. Once the effects of a policy themselves exert effects on the original policy one can speak of a feedback (Jordan and Matt 2014, 231; Schneider and Sidney 2009, 103). This study is concerned with feed-forward effects that may, potentially, lead to positive feedback effects, in the sense that there may be more political support as well as cognitive and institutional capacity for strengthening some of the original policies.\(^7\)

On the one hand, institutions enable and constrain individual choice and strategies. But beyond that, they also “affect the articulation of interests, and particularly the articulation of collective interests” (author’s own emphasis) (Thelen 2002, 92). As a result, institutional configurations play a role in facilitating the organisation of certain groups and contributing to the disarticulation of others. Institutions contribute to the emergence and decline of groups not only by affecting coalition formation but also by influencing the “capacities ... to recognize shared interests in the first place” (Thelen 2002, 92f.; see also Immergut 1998, 12; see also Schneider and Sidney 2009, 110).

I analyse rescoping as a *feed-forward effect*. A greater focus on feed-forward effects should help us to better explain the evolution of the regime complex on climate change, and identify how gradual change in specific areas may over time accumulate and unlock new policy opportunities.

\(^7\)If one wishes to adopt a rather broad view of the policy design category in questions, for example the climate change regime, then one could speak more of policy feedbacks (Jordan and Matt 2014, 235). However, for the sake of precisions, I choose to adopt a more narrow conceptualisation which focuses on individual policy types.
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As policies can have both redistributive\(^8\) as well as cognitive, or interpretive, effects, they can shape interest groups just as interest groups shape policies (Pierson 1993, 598, 610). Schattschneider already argued in the first half of the 20th century that “new policies create a new politics” (cited in Pierson 1993, 595). Later, Skocpol was an important initiator of the study of policy feedback, arguing that “as politics create policies, policies also remake politics” (cited in Jordan and Matt 2014, 228).

The study of interpretive effects looks at policies as sources of new information which may affect cognition, understanding and meaning (Jordan and Matt 2014, 228). This study pursues such a line of inquiry, too, but with an emphasis on the data intensive conditions for achieving the full strength of such effects.

In his much-cited review article, Pierson (1993, 600) draws on David Vogel’s (1989) argument that the attempts in the late 1960s and early 1970s at regulating US business conduct in a general rather than an industry-specific way had the effect that business executives became much more conscious of their common, or class, interests which ushered in the formation and revival of cross-industry organisations for the representation of business interest. Before Vogel, Laclau and Mouffe (2001) had already pondered from a ‘continental’ discourse-theoretical perspective how the creation of equivalences can affect the structuring of group identities in the political arena.

Based on these theoretical considerations one can then ask how policies or initiatives influence how information are distributed, and what impact this has on political divisions (see Pierson 1993, 611). Thus, when one takes such feedback and feed-forward effects into account, initiatives contributing towards capacity-building may have ripple effects on the conditions for coalition building, via material, institutional or cognitive pathways.

*Policy design* theory concerns itself with how the contents of policies (the ‘design’) emerge from political and social processes and how these contents, in turn, exert feed-forward effects onto the political process (Schneider and Sidney 2009, 105). Schneider and Sidney (2009, 103) suggest that the next generation of policy design theory pay more heed to the social construction of knowledge. While this would seemingly be already covered by the notion of *cognitive effects* (Pierson 1993, 598/610), it seems important to distinguish between relatively immediate, first order, cognitive effects, and those arising from longer term processes, which may develop in places more distant from the gaze of those analysts,\(^9\)

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\(^{8}\)These may also be called *resource* effects (Jordan and Matt 2014, 228).

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who remain fixed on the more overtly political realm. The notion of the *social construction* of knowledge helps to problematise the preconditions for such cognitive effects as the result of far from trivial processes of knowledge generation, coordination, contestation and institution-building. It is also important to look at the material and organisational aspects, which are more slow-moving, rather than just focusing on direct, seemingly quick, cognitive effects.

For the, necessarily diachronic, examination of feed-forward effects this study leaves the field of the outwardly political and descends, for a while, into the depths of the technical and managerial sphere, before, upon ascendance, to encounter a landscape marked by profound shifts in the cognitive and institutional capacity to obtain and exchange information on the emissions embodied in products.

How do different policy designs affect the conditions for the creation of information on embodied emissions? And how does the availability of information on embodied emissions affect the structure of policy deliberations? In order to conceptualise the implications as well as the challenges and opportunities arising from the different ways of engaging with interest groups, the attractiveness of which is partly structured by the rough shape of the policies to be elaborated, a staple continuum of political science comes in handy: that between pluralism and corporatism.

Many usages of these concepts have evolved and sprawled over time. Only alluding to the concepts risks being imprecise, defining them too narrowly runs the danger of failing to do justice to a rich tradition of research. While there are debates about the extent to which countries or sectors can be characterised as tending more towards the corporatist or pluralist side (Lijphart 1999, 158ff.), here I am more interested in the factors that contribute to more pluralist or corporatist *situations*. For my purposes here, I conceptualise corporatism and pluralism as less being features of specific national systems but more as contingent possibilities on a continuum between ideal types (on ideal types see Weber 1967, 193ff.).

What are these ideal types? In the following I draw on Falkner’s (2008, 12/42) contrasting depiction of pluralist and corporatist characteristics, but reframe them as attributes of *situations*: in pluralist situations competition between different interest groups creates a balance of interests that prevents any one group from entirely dominating a policy field. In contrast, in a corporatist situation, highly centralised interest groups are able to dominate a policy field.
3. Theoretical framework and research questions

by asserting a uniform position (see also Schneider 1992, 113).

Instead of corporatist and pluralist situation one may also talk about a continuum between heterogeneous or homogeneous structures of interest representation.

One can conceptualise these situations as arising on the basis of and feeding back to network structures. Different policy subsystems may be characterised by different network structures (Howlett 2002, 240). Corporatism and pluralism can be understood as ideal types of policy network structures, where policy network is formally understood as a set of links between points (Schneider 1992, 109f.).

Streeck (2006, 27) criticises neo-classical theory for being “unwilling to accept that there could also be a productive public use of private organized interests”. Instead, private interests solely contribute indirectly to the common good, “as a by-product of a free play of market forces” (Streeck 2006, 27). In the following I will not only make the case that information production, rather than an excessive economising on the requirements for it, has the potential to help establish the institutional foundations for better fulfilling the promises of carbon pricing. I will also argue that information provision opens up possibilities for policies complementary to carbon pricing, which can shift the locus of decision-making to a more material-neutral arena, with a more pluralist action situation (I borrow the term “action situation” from E. Ostrom 2010b). Whereas, for example, Helm (2010, 193) suggests the use of market-based instruments in order to limit the possibilities for capture of the policy process by organised interests (see page 50), Chapter 8 suggests that government engagement with sectoral associations for the purposes of voluntary agreements and standard setting catalysed an improved availability of life cycle information, thus indirectly improving the informational conditions for more technology and material neutral policies.

This argument can be formalised as the following proposition: a political environment that incentivises an intra-sectoral exchange on the environmental impacts of production will be conducive to the creation of sectoral life cycle data sets (see Figure 3.1).

Importantly, we may encounter different policy network structures in policy subsystems. The shape of these policy network structures is likely to be influenced by the value chain segment they are aligned with, and by the type of policy targeting them.

Falkner (2008, 38) points out that
3.4. Rescoping and its feed-forward effects on coalition-building

This study deals with how environmental regulations have informational reverberations through production chains, in the form of feed-forward effects which help to enable a shift of the locus of regulation from point to flow, from production to product, thus changing the conditions for coalition formation.

Bleischwitz (2004, 39) insists that “support from vested or newly-established interest groups” is pivotal for effective policy-making targeted at increasing eco-efficiency. For Newell and Paterson (2011, 41) “it is clear that ... strategies to address climate change have to engage with those that exercise power in contemporary capitalism. Identifying viable accumulation strategies and the political constituencies to support and realise them is vital to this enterprise.”

Pursuing a rather anti-regulatory agenda Smith and Yandle (2014) also argue that business support is often key for environmental legislation to be passed.

Due to the powerful role of business in environmental politics, it is of partic-
3. Theoretical framework and research questions

ular interest how policies and other initiatives can help to mobilise business in support for climate policy (Bleirschwitz 2004, 39; Falkner 2010; Jonas Meckling 2011b; Newell and Paterson 2011, 41; A. C. Smith and Yandle 2014). The field of renewable energy is a prime example of where the dispensation of subsidies helped to mobilise a business lobby in favour of more ambitious climate policy (Aklin and Uripelainen 2013; J. Meckling et al. 2015).

I argue that the layering of informational institutions can enable actual or potential policies to shift downstream and thus, accordingly, to exert modified differential effects in terms of the losses and benefits from policies and to also shift epistemic power to actors situated more downstream, from building material producers to project developers, architects and sustainable building certification scheme operators.  

This leads me to the following proposition: *information on product life cycle emissions facilitates relatively low carbon businesses to re-aggregate behind the low embodied emissions framing* (see Chapter 5).

Espeland and Stevens (1998, 323) suggest that, as commensuration establishes new interpretative frameworks, it can have political effects. As such, “it is not a neutral or merely technical process”. Similarly, Green (2013b) suggests that carbon disclosure and standard-setting might affect firms’ identities. This points to the interwoven nature of epistemology and politics (Jasanoff 2012, 12). By creating an equivalence between different activities and identities, an overarching frame such as ‘low-carbon’ can unite different actors under one banner.

For Jasanoff (2012, 16):

“science and technology are not only epistemic and material but also normative processes: they are part of the dynamic of building integrated understandings of how the world is and how it should function, with combined support from expert knowledge, material innovation, and political power.”

Might the *production* of knowledge on product life cycle carbon emissions have some substantial political effects? If yes, this could be seen as an instance of *productive* power, where “socially existing and, hence, historically contingent and changing understandings, meanings, norms, customs, and social identities ..

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9This is a general model, potentially applicable not only to further domains of climate and environmental politics, but also to other areas such as labour conditions, for which first social LCAs are in the making (Benoît-Norris et al. 2011).
3.4. Rescoping and its feed-forward effects on coalition-building

make possible, limit, and are drawn on for action” (M. Barnett and Duvall 2005, 56; on the power/knowledge nexus in earth system governance see Biermann et al. 2009, 68).

The notion of interpretive effects in the institutionalist realm of policy design and policy feedback studies resembles the notion of productive power. A primary distinction may perhaps be found in the somewhat more positivist bent of institutionalist scholarship, which focuses more on how changes in isolated parts of social ensembles effect change, whereas the holistic bent of those who employ the concept of productive power attends more to the interpretation of how ensembles of actors and institutions shape meaning and identities. While this study steers more towards the positivist side, I suggest that the whole may be bigger than its parts and that an important aspect of what I am investigating here may actually be operating at a more subtle level, shaping how subjectivities and narratives of the world are formed and amended.

In the present context, the notion of productive power is particularly useful as it provides a perspective on the epistemic basis for changing actor identities, such as providers of low whole-life carbon products and solution. The lens of productive power emphasises the importance of signification and meaning and networked social forces for the emergence of specific identities or rationalities of action (M. N. Barnett and Duvall 2005, 20).10

Many authors suggest that product-standards or subsidies (Vogel 1997; J. Meckling et al. 2015; Yandle and Buck 2002) can successfully mobilise business support in their favour. The expansion of feed-in tariffs for renewable energy has spawned its own lobby and has thus ushered in a self-reinforcing dynamic (Aklin and Urpelainen 2013). There is a clear constituency for energy efficiency standards and targets (Rosenow 2013). In both cases, concentrated groups can reap large benefits.

However, carbon pricing suffers from a reverse cost-benefit distribution. As a consequence, the ability of carbon pricing to catalyse the formation of coalitions

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10 Theories of productive power are associated with post-structuralism and particularly the work of Michel Foucault. The writings of Foucault have proven to be a continuing source of stimulation for analyses of the nexus between power and knowledge (Foucault et al. 1991; Foucault 2009; Raffnæs, Gudmand-Høyer, and Thaning 2016). Students who apply the Foucauldian power/knowledge or governmentality lenses, seek to reconstruct how the modes of classification arising from ‘regimes of truth’ inform and, thus, for better or worse, justify action (Jasanoff 2006, 278). However, this strand of inquiry tends to shy away from both the more positivist attribution of effects and more concrete proposals towards problem solving in the domain of policy. The present study pursues a different approach.
for stricter carbon policy to do the same is cast doubt upon (Yandle and Buck 2002; J. Meckling et al. 2015). Meckling et al. (2015, 1170) observe that “carbon regulation imposes costs on the powerful few—well-organized energy and energy-intensive manufacturing firms—and provides dispersed benefits to the weak many—the broader public”. As a consequence “carbon pricing may be ineffective for cultivating coalitions for stronger low-carbon policy”. Based on this finding, Meckling et al. seek to de-prioritise carbon pricing in favour of targeted policies designed to create concentrated groups of winners and relegate carbon pricing, economically more efficient yet politically lacking the property of creating its own constituency, to a later stage at which “carbon policy” may be more politically entrenched.\(^ {11} \)

Yet, by only looking at how ‘policy makes politics’ in a rather immediate way, one may overlook the indirect and unintended catalytic effects carbon pricing initiatives may have at later times and at other levels.

In order to work out how information might affect political divisions we need to be attentive to how it can affect the feasibility of regulation, i.e. how the feasibility of regulation mediates the effect of information on political divisions. The increased technical and institutional feasibility of measuring embodied emissions performance makes it a more realistic policy option and thus can help to define a line of conflict, which might come to characterise a political division.

As information structures the feasibility of different types of policy, these can be expected to vary with regard to crucial coordinates. By affecting the levels and the scope at which one can regulate a market, information provision should be able to affect the dynamics of coalition building via at least three mediating variables\(^ {12} \):

1. differential effects on firm
2. stakeholder legitimation
3. policy legitimation

Corporate support for or resistance to environmental policies can be largely explained by their differential effects on businesses (Falkner 2008; Jonas Meckling 2015). Vogel (1997, 560) suggests that domestic producers may be more

\(^{11}\)See Helm (2010) for a more orthodox economic perspective with suggestions for using market-based mechanisms with the explicit intention of reducing the effects of rent-seeking.

\(^{12}\)These effects need to be conceptualised as anticipatory, as it is not just an implemented policy that has effects but potential policies that are floated at the agenda-setting stage can have a similar effect.
3.4. Rescoping and its feed-forward effects on coalition-building

willing to support stricter regulations when they anticipate that their international competitors will bear a disproportionately greater share of the burdens of compliance.

The presence of benefits for the different coalition members is an important consideration for explaining coalition building, which, in turn, can be an important condition for policy success. The availability of information can be a key difference for policy to shift between the allocation of diffuse and concentrated benefits. This is important as public choice literature suggests it is more easy to mobilise actors in the pursuit of concentrated benefits or in resisting to concentrated losses rather than diffuse ones (Olson 1975, 2). A transformation of information on production-based emissions into product qualities can enable the emergence of product standards. As these have more clearly defined and concentrated beneficiaries (as suggested by Vogel (1997); J. Meckling et al. (2015); Yandle and Buck (2002)), this should also make them a more attractive proposition for carbon efficient businesses to rally behind them in support.

Once environmental policies are implemented, over time they can have horizontal, trans-state or transnational effects on coalition formation in environmental policy. The term ‘California effect’ was coined on the basis of the observation that the tightening of automobile emissions standards in the large and affluent market of California led to the tightening of other US state and national standards (Vogel 1997, 561). Vogel (1997, 561f.) suggests to use the term in a broader way, to describe the following phenomenon:

“Political jurisdictions which have developed stricter product standards often force foreign producers in nations with weaker domestic standards .. to design products that meet those standards ... [and] having made these initial investments, [foreign producers] now have a stake in encouraging their home markets to strengthen their standards as well, in part because their exports are already meeting those standards”.

Vogel (1997, 563) observes that “[t]he California effect primarily holds for product standards”. However, he also suggests that some production standards, for example the European eco-labeling schemes, can be turned into product standards. He even goes so far as to suggest that this, unlike direct actions targeted at changing production standards, would make them consistent with WTO rules (Vogel 1997, 565).
Policies vary in the scope of who is considered an important stakeholder in deliberations at the different stages of the policy cycle. This can affect how accessible lobbying is for different stakeholders, as policy-makers require different kinds of stakeholders input, both for technical as well as for political purposes (Broscheid and Coen 2007).

As different policies target actors in different ways, and use different approaches to achieve their aims, policy-makers depend differently on the unique information the regulated have about the issue at hand. For example, policy-makers would want to know whether a policy is technically feasible, and what is an optimal price, so that it induces greater efficiency or innovation while not undermining the competitiveness of an industry. Depending on who government officials deem qualified to make statements on such issues, they will consult different stakeholders.

For political purposes, policy-makers may want to consult those affected by a policy, in particular those organised interests that may powerfully oppose or support a policy. The scope of an intervention affects who could be potential veto players, in formal ways, or who would be likely to mobilise politically in favour or against an initiative and who policy-makers may thus want to consult in order to obtain information on the political feasibility of a proposal.

The availability of information can affect the ability to craft policy in more universalist, rather than particularist, terms. Policies that can be justified with reference to universal higher normative principles enjoy greater and wider legitimacy than policies that only serve particular interests (though not necessary more support).

Whether a policy is designed in more particular or more universalist terms impinges on the composition of interest groups, how they may be classified or how they may classify themselves. Where a higher level concept is used, a broader group may correspond to the scope of the policy. For example, ‘support for renewable energy’ is a more universal policy scope than ‘support for wind energy’ and support for ‘low or zero carbon energy’ is even more universal. Information-providing institutions can be important preconditions for the emergence of coalitions that are held together by an alignment of their particular interests with a more universal, collective, interest (drawing on Thelen 2002; and Bernstein 2011).

Whether a policy is targeted at a smaller (with more particular claims) or larger (with more universal claims) group is also bound to interact with the
3.4. Rescoping and its feed-forward effects on coalition-building

scope of who is designated a legitimate stakeholder and the distribution of costs and benefits. In empirical cases, all three aspects are likely to be interwoven.

Economic arguments involving spillover effects and complementarities can gain additional depths when located within social and historical contexts. Emphasising the relevance of economic sociology, Swedberg and Granovetter (2001, 18) argue that “economic institutions are constructed by the mobilization of resources through social networks, conducted against a background of constraints given by previous historical development [sic!] of society, polity, market, and technology”.

Such network effects need to be reckoned with in order to account for the way the emergence and institutionalisation of environmental monitoring and disclosure systems targeted at places or production or juridical entities have contributed to those of place-less systems (see Chapter 8 and Chapter 9). This applies to the connections between organisations, but also penetrates organisational boundaries, perhaps most importantly where the implementation of place-based monitoring and disclosure systems provides incentives to either recruit sustainability experts or for extant staff to engage with the sustainability curriculum. If one conceptualised firm strategies, identities and thus interests as fixed, it would make sense to only look at spillover effects and complementarities in terms of material or human resources. This, however, would neglect the agency of individuals who are embedded within organisations and extra-organisational networks to shape their organisation’s perspective in its environment.

Knowledge spillover effects are likely to be enmeshed with the boosting of ‘instrument constituencies’. Voß and Simons (2014, 238) point to the phenomenon of ‘instrument constituencies’ which they conceptualise as “actors and institutions [that] come to exist for and by [policy] instrument[s]”. Similarly Downs (1965, 444) in his Theory of Bureaucracy suggests a dynamic where “[e]ach bureau attempts to stake out, defend, and expand a certain ‘territory’ of policy related to its social functions”. There may be similar effects within trade associations and big companies to the one Downs has suggested. Where demand for certain skills increases, this creates jobs for people specialised in environmental issues, who may then go on to push for expanding the range of activities within their remit.

‘Instrument’ can be a broad term here, not only taking into account government policy instruments but also instruments of corporate or non-state gover-
3. Theoretical framework and research questions

Instrument constituencies can best be mobilised if the conditions are favourable for claiming that an instrument can help to solve a problem, i.e. if there is a potential demand for an instrument. On the other hand, the socio-technical conditions need to be ripe for the possibility of supplying an instrument. Where both supply and demand promise a successful action, actors are more inclined to act. Complementarities in skill sets or other attributes of such instrument constituencies, such as the norms they espouse, can also lead to spillovers, perhaps endowing an instrument constituency for corporate carbon disclosure with an interest in product level disclosure.

The term instrument constituency (Voß and Simons 2014) allows for a plurality of motives and actors and puts the emphasis not just on the process leading up to the introduction of an instrument but on the entire life span of an instrument and the different ways actors bring about the instrument or are brought about by it.

In the environmental domain, coalitions have been variously described as baptist/bootlegger coalitions (Jonas Meckling 2011b, 2015; Yandle 2012; Clapp and Meckling 2013), advocacy coalitions (Weible, Sabatier, and McQueen 2009), policy coalitions (Rozbicka 2013) or instrument constituencies (Voß and Simons 2014).

While all of these conceptualisations have their own merits, they also have their limitations for the issue at hand: The baptist/bootlegger framing (Yandle 2010) point out the alignment between values and interests which is often crucial for policy success, yet it is too much focused on one-off policy interventions, similar to policy coalitions (Szarka 2010). In addition, it’s primary focus is on the alignment between material interests and moral values\(^\text{13}\) rather than looking at the possibilities for different material or technology to re-align behind a common normative umbrella.

Advocacy coalitions (Weible, Sabatier, and McQueen 2009), on the other hand, focus too much on beliefs and downplay the strategic side of lobbying and collaborations between business, civil society and state actors. Studies in the tradition of the advocacy coalition frameworks also tend to neglect the specificities of concrete policy contents (Schneider and Sidney 2009, 113).

The problem with both the categories of identities and beliefs is that their credible attribution requires an in-depth analysis of the respective group or indi-

\(^{13}\)And the sustained cultivation of suspicion against government regulation (A. C. Smith and Yandle 2014).
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...individual. A more superficial analysis will rely merely on a few statements, however the motivations for uttering or releasing them may vary. Sometimes people may have an interest in publicly subscribing to a certain idea, and it would be misleading to draw from that the conclusion that their beliefs or identities are therefore such and such. Pragmatist (Boltanski and Thévenot 1999, 2006; Blok 2013) and institutionalist approaches can reconcile the role of ideas versus interests by acknowledging that individuals can be aware of a variety of different rationales and that they strategically deploy different modes of argumentation depending on the context. For example, when individuals switch between different organisations, the adoption of modes of argumentation that resonate with the new organisation may become a precondition for their successful integration. I thus adopt a position that does not concern itself with whether actors enter coalitions due to deeply held beliefs or in following opportunistic rationales. Their ‘identity’ also does not matter. It is more concerned with the informational preconditions for reasonably pursuing strategies which entail advocating for specific policies. ‘Reasonable’, here, denotes a certain correspondence between the technical feasibility of a policy and its political feasibility, as can be gauged from the extent to which it can resonate with established or novel interests and/or more universalist values. While this does entail a degree of interpretation, it rests on intersubjectively accessible norms and modes of argumentation rather than on needing to understand someone’s identity or beliefs.

Commensuration, and therefore knowledge creation, is an important aspect in the dynamics of coalition-building. Yet, the ‘learning’ that forms its base is highly contested and different coalitions emphasise different qualities of practices, materials or institutions as they develop and reproduce narratives which legitimise their favoured approaches. Hence, explanatory endeavours need to take into account the semiotic aspects of meaning-making and communication (Levy and Spicer 2013, 660; Jessop 2010).

There are many different, and constantly evolving, views on what constitutes more or less sustainable practices and technologies. Frame analysis allows to analyse these evolving views. The term ‘frame analysis’ was first put forward by Erving Goffman (1974), denoting the explanation of how we “locate, perceive, identify, and label” different events and situations on the basis of different “schemata of interpretation”. Writing about communication rather than policy studies, for Entman (1993, 50):

“To frame is to select some aspects of a perceived reality and
3. Theoretical framework and research questions

make them more salient in a communicating text, in such a way as to promote a particular problem definition, causal interpretation, moral evaluation, and/or treatment recommendation for the item described.”

Taking such semiotic concerns into account could be deemed a discursive-institutionalist endeavour (Schmidt 2008, 2010).

The concept of framing is a broad and fuzzy one. In this study, processes of framing and reframing relate to concepts which actors may espouse, be it to express their beliefs or to advance their particular interests. This use of framing differs from the more immediate framing effects in cognitive psychology, by which Kahneman (2013, 88) labels the phenomenon that “[d]ifferent ways of presenting the same information often evoke different emotions.” In contrast, my concrete use of the concept of frames is closer to but less expansive than Dryzek’s (1993, 222), for whom

“A frame of reference is akin to a language or even a culture shared by a tribe of experts.”

The use of the concept most suitable for this study is probably that of collective action frames, by which the social movement literature draws on Goffman’s “schemata of interpretation” in order to analyse the construction of, and contestation over, “action-oriented sets of beliefs and meanings that inspire and legitimate the activities and campaigns of a social movement organization” (Benford and Snow 2000, 614). The analytical lens used towards the framing activities of social movements can be usefully extended to the sustainability arguments of companies. In fact, the distinction between social movements and ‘green’ companies is hardly clear cut, and corporate lobbying of ‘brown’ companies has ever more taken on the cloak of social movements – so called ‘astro turf’ (Mayer 2017). With the mainstreaming of sustainability discourse into politics and corporations, frames that may have initially been associated with social movements have now diffused into the realms of statecraft and business (Lounsbury, Ventresca, and Hirsch 2003).14

Chapter 5 shows how, once the commensuration of environmental qualities into product carbon footprints is achieved, interests that otherwise rally be-

14The link to social movements may suggest an emphasis on beliefs. In contrast, I wish to retain an emphasis on the possibility for strategic uses of meaning.
hind the banners of different sustainability claims, can re-aggregate behind the common quality, or the frame, of relatively low embodied emissions.

3.5. Transaction costs, spillover effects and complementarities

Transaction costs are a key concept in the study of institutional change (Nee 1998, 1f.). North (1990b, 362) defines transaction costs as the “costs of measuring and enforcing agreements”. However, the costs of drawing up and making an agreement can also be considered as part of transaction costs (Hall and Taylor 1996, 943). Further expanding on this definition, Coggan et al. (2010, 1779) also subsume the research, information gathering and analysis efforts needed for the creation and use of environmental policies under the rubric of transaction costs. This, however, raises the question whether such a broad definition does not stretch the concept of transaction costs too far. For example Dahlman (1979, 147) builds on Coase’s (n.d.) definition of transaction costs:

“In order to carry out a market transaction it is necessary to discover who it is that one wishes to deal with, to inform people that one wishes to deal and on what terms, to conduct negotiations leading up to a bargain, to draw up the contract, to undertake the inspection needed to make sure that the terms of the contract are being observed, and so on.” (emphasis added)

to then argue that:

“A natural classification of transaction costs consistent with his definition can be obtained from the different phases of the exchange process itself.” (emphasis added)

However, when a government seeks to implement an environmental policy, there is a case to be made to at least be open to the possibility of treating this as an act of hierarchical imposition rather than as a market exchange. Such an action is not necessarily a transaction.\footnote{\textsuperscript{15}However, if we take it from the Latin verb transigere, one may as well subsume any cost that arises in the pursuit of action under the concept of transaction costs.}
3. Theoretical framework and research questions

I would thus argue that, where one looks at the informational requirements of government policy, it makes sense to solely refer to information and monitoring costs rather than transaction costs.

In contrast, the joint administration of information on firms’ or products’ environmental performance in sectoral associations requires the establishment of structures in which it is ‘agreeable’ to share information. Information also needs to be put into common formats, according to standards that need to be agreed upon. Insofar as reaching an agreement on these issues requires coordination, one can subsume the costs involved in successfully bringing about such coordination under the concept of transaction costs.

For Stiglitz (1987, 887) “technological change inherently involves increasing returns and sunk costs”. Sunk costs essentially “represent expenditures that cannot be recovered” (Stiglitz 1987, 894). For the purposes of this thesis it is less important whether expenditures can be recovered than whether they have already been made, and thus lower the costs for activities, which can subsequently build on the resources such acquired. I argue that investments into human and technological resources dedicated to the monitoring and reporting of production-based emissions represent sunk costs to varying degrees.

Durability is an important part of sunk costs, as a non-durable acquisition of resources would not be considered an investment and its costs therefore not as sunk (Stiglitz 1987, 894). Yet, although my focus is on the expenditure itself, the concept of durability is important. If compliance with production-based monitoring and reporting only requires a specific one-off transaction, for instance by delegating all the work involved to an external consultant, one cannot assume that an organisation acquires resources to such an extent that these would potentially then also benefit product-based disclosure. However, one could still assume that such delegation to external consultants will be registered as demand for the specific expertise of such consultants and thus leads to incentives for building up and retaining such expertise.

While the investments made into processes and technologies for the monitoring and reporting of production-based emissions may be of varying degrees of durability, they must occur somewhere. Whether an organisation itself makes more durable investments or outsources these to external consultants and software providers, who offer temporary licences or host their solutions in the cloud, does not affect the fact that there is a build-up of resources, which may be used for complementary activities. It only affects where such a build-up occurs.
3.5. Transaction costs, spillover effects and complementarities

If there is a considerable complementarity of assets between production based environmental monitoring, on the one hand, and reporting and product-based life cycle disclosure of environmental impacts, on the other hand, there would be a good case that increasing returns to scale may facilitate such rescoping from point to flow. Stiglitz (1987, 927) uses an example from inter-firm competition in order to explain increasing returns to scale:

“A discovery that reduces the cost of producing widgets by $1.00 is worth $1,000 a year if 1,000 widgets are produced each year, but $10,000 a year if 10,000 widgets are produced each year.”

This certainly can make investments into emissions monitoring and reporting capacities more affordable for bigger companies. Yet, this example is about the upscaling of production, rather than a complementary use of assets between two related yet different activities.

One of my main arguments for explaining the rescoping from place-based to place-less environmental disclosure is based on the causal mechanism of spillover effects. The study of spillover effects is largely rooted in economics but has also made its way into the analysis of institutional development in political science.16 Pierson (2000, 255) draws on economic examples when he suggests that a spillover occurs when improvements in activity \( a \) can lower costs for or increase the productivity of activity \( b \). Where the benefits flow back, by improvements in activity \( b \) then also lowering costs for or increasing the productivity of activity \( a \), we can speak of complementarities. Such complementarities can then become the source of increasing returns (Pierson 2000, 255). Spillovers and complementarities can occur within and between similar or different organisations. Organisational complementarity can result in institutional complementarity. The concepts of organisational and institutional complementarity are key building blocks for understanding processes of institutional evolution.

This leads to the following proposition: production-based environmental monitoring and reporting has spillover effects and thus drives down various costs for eventual product level disclosure of life cycle impacts (see Chapter 9).

16Cross-country spillovers of environmental technologies are also a staple of the literature closer to environmental policy (see e.g. Tarui and Polasky 2005; Perkins and Neumayer 2009).
3. Theoretical framework and research questions

Referencing North, Pierson (2000, 255) points out that

“In contexts of complex social interdependence, new institutions often entail high fixed or start-up costs, and they involve considerable learning effects, coordination effects, and adaptive expectations.”

Where institutions need to be set-up de novo this can entail large initial setup costs (North 1990a, 95). In the case of production-based emissions monitoring and accounting, a range of inter and intra organisational institutions need to be set up in order to perform this role properly: somebody needs to be tasked with implementing and operating emissions monitoring and reporting, somebody else with verifying the emissions. This can result in learning effects, or a build-up of cognitive capacities, both within reporting organisations and amongst the ranks of experts advising them. Reports become more comparable when they are in compliance with specific standards. To reach such comparability, coordination is necessary.

Such set-up costs make prior developments with complementarities causally more important as conditions for another event to occur with greater probability or to greater extent. Production-based monitoring, reporting and verification may thus have a catalytic effect on the emergence and diffusion of product-based disclosure.

When people observe that a practice based on a specific institution is becoming more prevalent, they will tend to adapt their expectations to assume that there is some permanence to the underlying rule (North 1990a, 95). This could lead to a normative spillover from production to product-based environmental monitoring and reporting.

Is product-based disclosure merely an extension of production-based disclosure? If so, we might simply investigate the matter in terms of a quantitatively increasing return: where production-based disclosure is already set up, learning
has occurred, and a standard has been coordinated, product-based disclosure could benefit from this infrastructure. The relative costs of yet another ‘unit’ of disclosure would be cheaper, in accordance with the ‘law’ of increasing returns. Thanks to initial investments into production-based disclosure, product-based disclosure would become more attractive. The additional benefits of product-based disclosure would perhaps also increase returns to the investments initially made solely to support production-based disclosure, helping to lock in the latter.

However, such an assumption would be premature. One cannot simply assume that both practices are essentially of the same kind. For the purposes of this investigation, I will treat them as distinct practices, potentially with a number of overlapping features.

3.6. Research questions and propositions

If an elemental regime governing embodied emissions is already existent, what have been the conditions that have fostered its emergence and growth, and what factors have been holding it back? Going beyond questions of governance, one would also like to examine the politics of the emerging regime complex. What are the political dynamics that have supported the emergence of the nascent regime and how, in turn, does the nascent regime affect political dynamics? How does the specific design of policy options affect who mobilises in their favour?

In order to be better able to explain the emergence of the regime complex so far and to make reasonable assessments of the conditions for further development or blockage, we need to look at the interplay between institutional and political dynamics.

Looking at the institutional aspects, one may wish to inquire into the conditions for the supply and demand of the information that is required for novel policies tackling embodied emissions to draw onto:

- How have policies contributed towards commensuration processes and how does such commensuration open up opportunities for the emergence of novel policies?

- What is the relation between economic incentives, in the form of pricing mechanisms, and regulatory approaches taking the form of standard-setting? Are they really just either alternatives or complements, or may the introduction of one perhaps help to prepare the feasibility of the other?
3. Theoretical framework and research questions

Can the adoption of a path-dependency perspective help to better appreciate this relation?

- What policies have contributed to the rise of EPDs and PCFs? On what basis could institutions be built that provide incentives for the use of EPDs/PCFs? What have been the institutional preconditions for companies and LCA consultants to have the informational ‘raw material’ ready to produce EPDs?

- What is the evidence for the emergence of a novel policy type in the form of product standards taking into account embodied carbon emissions? What are relevant features of such a new environmental policy?

Looking at the political aspects, one would like to know how processes of carbon commensuration affect the construction of new issue framings and corresponding interest group constellations:

- How can new policies provide modified political opportunity structures for the mobilisation of actors for more ambitious climate action? How have commensuration processes allowed new coalitions to emerge?

- How do processes of carbon commensuration affect the articulation of collective values and interests? What frames are advanced by different actors? What kind of particularity or universality do they have?

Looking at the triangle of actors, policies and information together: What evidence exist for policies and initiatives aimed at measuring and regulating environmental pollution to have led to catalytic sequences where commensuration processes involving normative change and capacity building ushered in new dynamics of coalition building in the area of climate policy?

Drawing on the aforementioned conceptualisation of how commensuration processes can affect coalition building, Chapter 5 asks who can be mobilised in support of policies that address embodied emissions? And how do variations in policy design affect who can be mobilised as supporters? I advance the proposition that information on product life cycle emissions facilitates relatively low carbon businesses to re-aggregate behind the low embodied emissions framing, and specify sub-propositions for different policy designs.

Chapter 6 asks how energy efficiency policy has affected the informational basis for the governance of embodied emissions? Drawing on the above consideration
3.6. Research questions and propositions

of commensuration processes, the different modes of institutional change and the
typologies of scaling and entrenchment, I advance the proposition that energy
efficiency policy has indirectly helped to improve the informational basis for
addressing emissions embodied in building materials.

Chapter 7 asks how important is data availability and quality for the accep-
tance of EPD-based policies? It then provides the rationale for undertaking
the informal-institutionalist analysis of the following chapters by advancing the
proposition that the availability of standardised quality information on embod-
ied emissions is an important criterion for the legitimacy of policies addressing
embodied emissions.

Chapter 8 asks what have been informational push factors for EPDs issued
by sectoral associations? It draws on transaction cost arguments to advance
the proposition that a political environment that incentivises an intra-sectoral
exchange on the environmental impacts of production will be conducive to the
creation of sectoral life cycle data sets.

Drawing on the above discussion of spillover effects Chapter 9 asks: do obliga-
tions for companies to report on their environmental performance have spillover
effects on their ability to disclose product level data? It then evaluates evidence
for the proposition that production-based environmental monitoring and report-
ing has spillover effects and thus drives down various costs for eventual product
level disclosure of life cycle impacts. While empirically testing arguments re-
lated to costs and capacities, it also discusses how the concept of ‘instrument
constituencies’ may help to account for some more subtle spillover effects in
terms of motivations or predispositions.

LCA experts often rely on ‘background’ databases for estimating the envi-
ronmental life cycle impacts of products. Chapter 11 asks: what are the links
between production-based monitoring and reporting and the availability of data in
such background databases? It then tests the proposition that production-based
monitoring and reporting has significantly contributed towards the availability
of data in background databases. The chapter is centred around the idea that
certain environmental policies improve the data basis for subsequent policies.
The concept of triangulation plays a key role.

I will use most of the different theoretical elements introduced in this chapter
to directly tackle the questions in the subsequent empirical chapters. However,
some of them serve to elucidate the relations between the empirical chapters,
and they will only be taken up, again, in the final discussion.
4. Methodology

My research design is problem-driven rather than oriented towards expanding a certain theoretical framework or showcasing, or improving upon, a particular method (Shapiro and Wendt 2005, 11ff.). At the core of my methodology lies the reconstruction of the institutional conditions for novel forms of coalitions advocating for a greater role for embodied emissions. Accordingly, I trace how information flows between different institutions, and I identify some of the major reasons for why the way these institutions supply and demand information has been changing over time.

This research has been largely explorative in nature, as a large part of the study consisted in exploring and evaluating causal links, and gathering evidence for their plausibility in order to bring knowledge that usually reside with experts with more technical backgrounds into the domain of global environmental governance scholarship.

In order to bring knowledge of the emerging regime of EPDs and PCFs, and its relation with established environmental policy approaches, into the domain of environmental policy and governance research I choose to portray the entire value chain, from the generation of LCA-relevant information to those actors who advocate for their increased use in policies. Any treatment in isolation would run the danger of failing to account for the mutual relations between different links in this chain.

Studies that rely on elite interviews and archival research are amongst the dominant strands of policy studies (Schneider and Sidney 2009, 115). A large part of this study follows that tradition, but there are also more quantitative elements. Often, methodological challenges arose because the causal linkages implied by the propositions are often not directly observable, or knowledge about them would be widely distributed across experts, most likely with different experts or practitioners only having had direct experiential access to specific changes at certain points in time. This chapter describes how the thesis evaluates the different propositions with a multi-method mix, consisting of process
4. Methodology

tracing, document analyses, qualitative and quantitative text analyses, network analysis, and interviews. It provides an overview of the different methods and how they inform the different chapters. To allow a better understanding of how the different methods were applied within their specific empirical contexts, the individual chapters often contain more details on the methods.

4.1. Matching propositions and methods

The following describes how I examine the core propositions with different research methods:

- **Proposition 1**: *Information on product life cycle emissions facilitates relatively low carbon businesses to re-aggregate behind the low embodied emissions framing* (see Chapter 5)

  Here, I used a network analysis to empirically test some of the underlying sub-propositions, which specify the differential effects of variations in policy design.

- **Proposition 2**: *Energy efficiency policy has indirectly helped to improve the informational basis for addressing emissions embodied in building materials* (see Chapter 6)

  The evidence for this proposition takes the form of a cross-national comparative process tracing, supported by analyses of primary and secondary literature and interviews.

- **Proposition 3**: *The availability of standardised quality information on embodied emissions is an important criterion for the legitimacy of policies addressing embodied emissions* (see Chapter 7)

  Evidence for this proposition comes in the form of a descriptive historical account and selected actor statements, supported by analyses of primary and secondary literature and interviews. A keyword analysis of a large number of documents as well as a network analysis support the historical account.

- **Proposition 4**: *A political environment that incentivises an intra-sectoral exchange on the environmental impacts of production will be conducive to the creation of sectoral life cycle data sets* (see Chapter 8)
4.1. Matching propositions and methods

In support of this proposition the chapter first establishes a substantial temporal overlap between sectoral information exchange in the context of the IPPC process and the release of sectoral LCA information. It then takes the case of the cement sector to trace processes leading from actual or anticipated policies, over sectoral information exchange to the release of sectoral LCA and EPD data. In doing so it draws on a multi-method mix comprising document analysis, semi-structured interviews, and quantitative text analysis in the form of dictionary methods and topic modelling.

- Proposition 5: *Production-based environmental monitoring and reporting has spillover effects and thus drives down various costs for eventual product level disclosure of life cycle impacts* (see Chapter 9)

To empirically validate the underlying sub-propositions, the methodology is split between an analysis of the impacts of the institutional environment on the firm level, on the basis of an analysis of CDP survey results, and an analysis of how such impacts may affect the propensity of firms to produce EPDs and PCFs, based on interviews as well as primary and secondary literature, and social network data.

- Proposition 6: *The collection and validation of data for the disclosure of the life cycle impacts of a product is somewhat expensive* (see Chapter 9)

This proposition is supported with a number of interviews as well as by primary and secondary literature.

- Proposition 7: *Energy efficiency and / or carbon policy indirectly help to generate higher quality carbon footprint data as they stimulate the diffusion of better energy metering equipment* (see Chapter 10)

Supporting evidence in favour of the above proposition comes in the form of interviews as well as secondary and grey literature. I also present some results of an automated quantitative content analysis of the CDP survey, conducted via keyword searches.

- Proposition 8: *Production-based monitoring and reporting has significantly contributed towards the availability of data in background databases* (see Chapter 11)
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Evidence for this proposition comes in the form of a reconstruction of how different production-based environmental monitoring and reporting mechanisms have contributed to the availability of life cycle inventories (LCIs) in databases, based on interviews and document analysis.

4.2. Case selection and timeframe

The chapters differ in their regional and sectoral foci, depending on the aspect of the governance of embodied emissions which I sought to elucidate.

The focus on the building sectors in Germany, the UK and the USA (in here in particularly California) in Chapter 5, Chapter 6, and Chapter 7 is due to the existence of pro-regulatory networks that advocate for greater consideration of embodied emissions. Crucial differences in environmental policy and policy advocacy between California, Germany and the UK make these regions attractive cases for comparison: California differs substantially in the relevant policy content from the other two cases. Whereas the Buy Clean California coalition has advocated for carbon benchmarks for intermediate products, British and German coalitions have advocated for whole-building standards. Whilst British energy efficiency ambitions have suffered a setback with the abandonment of the zero carbon home policy, the German government has maintained energy efficiency ambitions more continuously.

While the cases I chose are highly instructive, other country experiences would also be worthwhile to examine: Norway and Sweden, with their great number of EPDs according to EN 15804 and in particularly Sweden as an early pioneer in the development of an EPD programme, would certainly be worthy of deeper inquiry. Legislation requiring building level LCA for new builds in the Netherlands (Anderson 2018; Scholten and Ewijk 2013, 245) also makes that country an intriguing case for further study. The EPD initiative of the French government has already received a lot of attention and would certainly be worthy of more.

Chapter 8 first zooms out from the building sector to analyse potential causal links leading from structured information exchange processes, between industry associations and the European Commission, to the creation of sectoral LCAs. The chapter then goes on to explore the mechanisms behind such links by focussing on the case of the cement industry, both transnationally and for the cases of Germany, the USA and the UK. Crucial differences in government-
industry relations between the European cases and the USA make this a fertile
collection.

Chapter 9 adopts a global, cross-sectoral approach in analysing a large num-
ber of statements from companies headquartered in diverse countries, with the
purpose of gathering systematic data on how emissions reporting requirements
lead to changes within companies, which may affect their capacity to disclose
the environmental impacts embodied in their products.

Chapter 10 also adopts such a global, cross-sectoral approach to establish how
energy efficiency inducing policy can indirectly facilitate the creation of PCFs,
mediated via the adoption of sophisticated energy measurement devices. Most
of the empirical examples, however, are from North America and Europe.

Chapter 11 focuses on how diverse environmental initiatives and policies have
contributed to the availability of data in life cycle data bases. Such data has
come mainly from Europe and the USA.

While the narrative sometimes goes back to the 1970s, the main focus is on
the period from the mid 1990s, when the measurement of embodied emissions
and concern about them started, up to 2017.

4.3. Network analysis

Who advocates for embodied emissions policies? What is the relation between
different embodied emissions policy designs and the composition of the corre-
sponding advocacy networks? I used network analysis to examine these ques-
tions.

In a first step, I sought to include all relevant actors involved with organisa-
tions or initiatives advocating for embodied emissions policies. This required
in-depth research of the policy field. A tension arises between the aim to ‘ob-
jectively’ include all of the members of the advocating organisations and the
member organisations of member organisations and the need to limit the range
of units to be included in the analysis in order to not unduly ‘dilute’ the network
with organisations that may be too removed from the network to be considered
active advocates. Solving this tension requires some subjective judgement. By
transparently documenting which nodes were included in the network analy-
sis and by providing evidence which contextualises their selection, I limit the
subjective element and open it up to challenge by other scholars.

After having established a database with the members of the relevant or-
4. Methodology

ganisations and initiatives, as well as the members of some of their member organisations, I made sure to reconcile different denotations of the same organisations, including those caused by spelling mistakes, by using different fuzzy matching algorithms provided by OpenRefine (Groves 2016). I did not leave any decisions to the algorithms but supervised the entire reconciliation process.

I performed the concrete analysis with a number of packages for the statistical programming language R (Csardi and Nepusz 2006; Wickham 2009), which helped to cluster the networks into different communities (Harenberg et al. 2014). This allowed me to identify major differences with regard to the presence of the wood sector in the different networks.

I also calculated the actors with the most outgoing links to initiatives and organisations related to embodied emissions advocacy, which demonstrates the interest of service providers in embodied emissions advocacy and standard setting.

I identified ‘typical’ representatives of the German, UK and US networks and coded their members on the basis of the materials or services they are mostly associated with, in order to find out more about their internal composition, and how that composition varies across the Atlantic. Together with the overall network analysis, this allowed me to empirically confirm my propositions about the relation between policy design and the composition of advocacy networks.

4.4. Process tracing

The methodological approach results from the theoretical framework. The examination of how policies exert feed-forward effects in the form of rescoping requires to trace exactly these processes (on this requirement see Jordan and Matt 2014, 236).

I conducted a large-scale process tracing (Collier, Brady, and Seawright 2010) in order to better understand the emergence of the conditions for novel alliances demanding the inclusion of embodied emissions in building standards. Depending on the approach of the different chapters, I either elaborate the underlying mechanisms in the form of a series of causal sequences, of propositions linking different variables or by tracing the historical preconditions for specific actions.

One needs to distinguish between the identification of plausible causal mechanisms, causal mechanisms that have actually empirically manifested and causal mechanisms that have substantially contributed towards historical
developments. While the following identifies a range of causal mechanism that do have empirically manifested, this is different from claiming that they have exerted the historical force that has helped to bring about the phenomena under investigation. Yet, by identifying that such mechanisms are not only plausible but have also, indeed, manifested, one can be more confident that they could be important elements of path-dependent causal sequences towards transformative decarbonisation, which may help to select approaches when designing policy or orchestrating governance.

4.5. Document analyses

I analysed a large number of primary documents, including the statements from 600 companies to the CDP survey, industry position papers, technical LCA literature, actual EPDs, and other documents, as well as secondary literature. My archive for primary documents was the World Wide Web (WWW), which was convenient as the birth of the WWW more or less coincides with a large portion of the events detailed in this study. Relying on web-based resources runs the danger of being less than rigorous, as the availability of sources can be in flux, with ‘link rot’ threatening to undermine efforts at firmly establishing, and sharing, the basis for one’s arguments. I therefore opted to archive the websites I draw on for the empirical part in internet archives, such as Perma.cc. Insofar, the ‘archival’ research has also been ‘archiving’ research.

4.5.1. Qualitative-quantifying text analysis

Chapter 9 examines evidence for various sub-propositions of Proposition P5 *Production-based environmental monitoring and reporting has spillover effects and thus drives down various costs for eventual product level disclosure of life cycle impacts.*

In order to test whether requirements for the monitoring and reporting of carbon emissions at the firm level increase data availability, expertise, as well as technological and institutional capacities at the firm level I analysed statements by hundreds of companies that provide information to CDPs annual survey. I systematically coded the company statements in the CDP survey with the text analysis software MAXQDA (on coding see Boyatzis 1998).

1https://perma.cc
4. Methodology

There are advantages of a qualitative analysis over purely quantitative analysis of the CDP data. As part of the CDP data can just be selected by way of multiple choice, some of the results might be due to neglect or misunderstanding. By focussing on a qualitative analysis of statements, it is more likely that those who filled out the survey questions deliberately addressed these issues rather than simply ticking boxes, the content of which they may not have understood. The qualitative statements also provide some evidence, which could be proven wrong and which may lead to liabilities, whereas the pure ticking of boxes might be rather insulated from any potential claims arising from it.

In the analysis the absence of statements pointing to certain aspects does not imply that they are absent in companies. It only tells us that the person who was responsible for filling out the CDP survey did not include a statement, for whatever reason.

The CDP survey provides companies’ statements on the risks and opportunities associated with different climate policies. In 2015, the overall CDP dataset exceeded 10,000 companies, including those who did not reply to the survey. There were 1896 organisations in the flagship Investor CDP dataset, which comprises publicly disclosed data collected on behalf of investors. There were 2209 organisations in the CDP supply chain dataset, which comprises data by companies responding publicly to an information request from their clients, who are members of the CDP supply chain initiative. I limited my analysis to the Investor CDP dataset. Access to the CDP datasets is provided via an agreement between UCL ISR and CDP.

Sometimes different companies which seem to belong to the same conglomerate have individual entries in the CDP survey. These are all treated as individual cases.

4.5.2. Quantitative text analysis

Initially I had planned to complement the current study with more large scale semi-automated quantitative text analyses. However, the discourse about embodied emissions is still relatively marginal and I found a more qualitative approach to be more useful at present. There are, however, some examples of these quantitative text analyses in the present study. This section explains their methodological background.

The Internet Archive offers historical versions of organisations’ websites. One can write special scripts that allow to download all available text data in the
most common text formats. With most of these files, the text can be easily extracted with software tools. Some .pdf files may require Optical Character Recognition (OCR). This is more computing-intensive and I refrained from using my resources in this way. I applied an automatic language recognition algorithm to only select English-language documents. The automatic identification of duplicates, via the application of MD5 hash keys (Figuerola et al. 2011), allows to allocate documents only to the first year where their occurrence is documented and, thus, to assemble time series of text corpora.

I downloaded all available data in the most common text formats\(^2\) for the years 1996–2016 from the Internet Archive and kept all English-language documents with at least 50 words. I only considered PDFs where the text could be directly extracted without OCR. I conducted the usual preparatory steps for quantitative text analysis such as the removal of stop words and the stemming of words (Welbers, Van Atteveldt, and Benoit 2017; Jockers 2014; Benoit 2018).

The Wayback Machine has become recognised as a powerful resource for social science research (Arora et al. 2016). However, Leetaru (2015) warns that there is little understanding of the Internet Archive’s Wayback Machine, of what it archives when and how it might be biased. A further limitation of data representativity is introduced by the lack of a standardised tool for downloading the Wayback Machine’s content. The project rested on the use of an open source Ruby script, the reliability of which in downloading all content cannot be fundamentally confirmed.

In Chapter 8, Section 8.5, I employ quantitative text analysis in the form of a dictionary analysis. Here digital text is systematically scanned for the occurrence of specific keywords (Welbers, Van Atteveldt, and Benoit 2017).

Chapter 8 employs a topic model for the analysis of a large number of documents.

How can one quantify the relative prevalence of topics within the corpus of documents produced by certain sectors, apart from reading and coding all the texts? A reading of the documents that talk about different issues does not get one far. By focusing on the documents that do mention specific topics, we can only analyse how issues are framed within these documents but cannot obtain overall corpus-level prevalence metrics. A topic model can show the topic prevalence over time.

Novel methods for automatic text retrieval and quantitative text analysis al-

\(^2\) File formats: .doc, .docx, .pdf, .txt, .xls, .xlsx, .html, .htm, .ppt, .pptx, .odt, .rtf, .asp
4. Methodology

...trace differences in topical prevalence in systematic ways. Since the early 2000s a number of automated text clustering algorithms known as topic models have risen in prominence. Topic models enable researchers to discover common topics in large text corpora. The most prominent of these topic modelling algorithms is Latent Dirichlet Allocation (LDA).

In this study I applied the Correlated Topic Model (CTM) algorithm (Blei and Lafferty 2007), as performed by the R package for the Structural Topic Model (STM) (Roberts et al. 2013; Roberts, Stewart, and Tingley 2018; Wang, Zhang, and Zhai 2011). The CTM algorithm seeks to allocate all words and documents to a user-specified number of topics. There is no ‘true’ number of topics for any given corpus. While some automatically derived metrics for model and topic quality exist, human expert knowledge is key for finding a model that summarises the documents in a semantically coherent and substantively interesting way (Roberts, Stewart, and Tingley 2016, 58). The optimal number of topics depends on both the size and topical make-up of the corpus as well as the research questions. If the number of topics is rather small, potentially different topics, which could usefully be analysed in separation, may be lumped together in one. If the number of topics is rather large, the specificities of the individual texts come to the fore and may render topics too idiosyncratic for meaningful insights. Thereby, the advantages of aggregation are diminished.

The fact that the application of the CTM does not rely on topics or keywords specified by the researcher has two important consequences for the research results and the research process. First, all of the text within a corpus is analysed. This is in stark contrast to the generation of descriptive statistics based on selected keywords. This provides a perspective on the data that is less biased by prior assumptions.

Second, due to the fact that all the data is analysed, the researcher should ideally be equipped with some knowledge of the domain under investigation in order to detect meaningful clusters of keywords in the form of ‘topics’. As the approach is data-driven, this domain-specific knowledge can also be obtained during the research process on the basis of familiarising oneself with the words that make up the topics.

I provide two metrics for topic prevalence. For each document, the model estimates the proportion to which it comprises each topic. I aggregate this information by summarising all documents associated with a specific year. For each year, I present topic proportions normalised by number of documents and...
by the length of the documents. For the topic proportions normalised by number of documents I sum up all topic proportions for a specific topic across the documents of a year and then divide it by the overall number of documents for that year. This gives us the average topic proportion of documents for that year. For the topic proportions normalised by the length of the documents, I first multiply the topic proportion with the document length and sum up the results for each year. I then divide the result through the overall document length.

4.6. Interviews

Interviews can provide important, context-specific information, and help to better understand events at the micro-scale. I mostly use interview results complementary to document analyses, to corroborate and support statements, and sometimes as the main sources of information.

I conducted a range of expert interviews (Leech 2002; Aberbach and Rockman 2002; Berry 2002; Dexter 2006; Froschauer and Lueger 2009). The first wave of interviews was rather exploratory in outlook, seeking to better understand the field of sustainable construction as well the cement and steel industries. Here I relied on convenience sampling, the limited response to an initial broad targeting of the steel sector, and snowball sampling.

The second wave of interviews was aimed at the testing of propositions, focussing more on LCA and green building certification scheme experts, advocates for embodied emissions policies and experts on cement sector carbon measurement. Here I deliberately chose organisations key to my analysis and / or experts with considerable expertise and standing in their field.

Most of these were semi-structured in-depth interviews with often very technical questions. The questions varied, depending on the professional role of the interviewees, and they evolved with the research project. Interviews lasted for at least 20 minutes and most of them for at least an hour. I conducted most of the interviews in person, on the phone, or via Skype, and some of them via email or chat.

It was not always easy to get access to interviewees. Sometimes I drew on my professional network in order to get access to some of the more high profile interviewees, either to obtain contact details or introductions. There was also a considerable element of snowballing involved, where some of the interviewees
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spontaneously introduced me to other interviewees. I also went to trade fairs and conferences, which helped to win otherwise unresponsive experts over to provide me with interviews.

I provided participants with information about the research project, sought their informed consent and offered respondents to go on record with their own name, that of their organisations or to stay entirely anonymous. While some experienced respondents gave me permissions, during and after the interview, to cite their statements directly, I provided most of the interviewees, whose names or organisations I disclose, with transcripts of the interview and asked them to confirm that I may attribute the statements to them or their organisation.

Several times I would ask interviewees for clarification or additional information after the interview, sometimes as part of the transcript clearance process.

Where possible I sought to triangulate interview results with other interviews or primary or secondary sources (Denzin 1978, 2012; Blaikie 1991; Flick 1992; Creswell and Miller 2000).

Altogether I interviewed 37 experts for this study. Table 4.1 shows the experts, ordered by their respective organisations.

<table>
<thead>
<tr>
<th>Interviewees</th>
<th>Organisation</th>
<th>Position</th>
<th>Year</th>
<th>Region</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gary Newman</td>
<td>Association for Sustainable Building Products</td>
<td>Executive Chair</td>
<td>2017</td>
<td>UK</td>
</tr>
<tr>
<td>Anonymous</td>
<td>Association of German Cement Plants (vdz)</td>
<td>Staff member</td>
<td>2017</td>
<td>Germany</td>
</tr>
<tr>
<td>Anonymous</td>
<td>Bau Fritz</td>
<td>Senior representatives</td>
<td>2017</td>
<td>Germany / Europe</td>
</tr>
<tr>
<td>Morgan Jones</td>
<td>Carbon Trust</td>
<td>Associate Director</td>
<td>2017</td>
<td>UK / Global</td>
</tr>
<tr>
<td>Anonymous</td>
<td>Ceres</td>
<td>Senior representative</td>
<td>2017</td>
<td>USA</td>
</tr>
<tr>
<td>Anonymous</td>
<td>DGNB</td>
<td>Staff member</td>
<td>2016</td>
<td>Germany</td>
</tr>
</tbody>
</table>
### 4.6. Interviews

<table>
<thead>
<tr>
<th>Interviewees</th>
<th>Organisation</th>
<th>Position</th>
<th>Year</th>
<th>Region</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anonymous</td>
<td>EcoInvent</td>
<td>LCA expert</td>
<td>2017</td>
<td>Switzerland / Global</td>
</tr>
<tr>
<td>Anonymous</td>
<td>European Commission</td>
<td>Carbon pricing expert</td>
<td>2016</td>
<td>European Union</td>
</tr>
<tr>
<td></td>
<td>DG Clima</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anonymous</td>
<td>European Commission</td>
<td>Staff member</td>
<td>2016</td>
<td>European Union</td>
</tr>
<tr>
<td></td>
<td>DG Environment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anonymous</td>
<td>European Commission</td>
<td>Sustainable buildings</td>
<td>2016</td>
<td>European Union</td>
</tr>
<tr>
<td></td>
<td>DG Growth</td>
<td>expert</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anonymous</td>
<td>European Commission</td>
<td>Cement expert</td>
<td>2016</td>
<td>European Union</td>
</tr>
<tr>
<td></td>
<td>DG Growth</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anonymous</td>
<td>European Commission</td>
<td>Steel expert</td>
<td>2016</td>
<td>European Union</td>
</tr>
<tr>
<td></td>
<td>DG Growth</td>
<td></td>
<td></td>
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</tbody>
</table>
4. Methodology

<table>
<thead>
<tr>
<th>Interviewees</th>
<th>Organisation</th>
<th>Position</th>
<th>Year</th>
<th>Region</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neil May</td>
<td>Former director of the ASBP, Senior Research Fellow at UCL, used to be a member of several Government Advisory bodies at DTI, DCLG and DECC, inter alia for the Code for Sustainable Homes.</td>
<td>Sustainable buildings expert</td>
<td>2016/2018</td>
<td>UK</td>
</tr>
<tr>
<td>Danny Püschel</td>
<td>Gebäude-Allianz (Building Alliance) and NABU coordinates the department responsible for EPDs in a company that produces LCAs for buildings and building materials / coordinator of Building Alliance for NABU</td>
<td>2017</td>
<td>Germany</td>
<td></td>
</tr>
<tr>
<td>Anonymous</td>
<td>Germanwatch</td>
<td>Staff member</td>
<td>2015</td>
<td>Germany</td>
</tr>
</tbody>
</table>

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### 4.6. Interviews

<table>
<thead>
<tr>
<th>Interviewees</th>
<th>Organisation</th>
<th>Position</th>
<th>Year</th>
<th>Region</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bruno Vanderborght</td>
<td>Holcim (formerly)</td>
<td>former Head of Climate Change</td>
<td>2017</td>
<td>Switzerland / Global</td>
</tr>
<tr>
<td>Anonymous</td>
<td>IBU</td>
<td>Senior representative</td>
<td>2017</td>
<td>Germany</td>
</tr>
<tr>
<td>Anonymous</td>
<td>Independent advisor and professor</td>
<td>Sustainable building expert</td>
<td>2016</td>
<td>UK</td>
</tr>
<tr>
<td>Anonymous</td>
<td>Institut Bauen und Umwelt (IBU)</td>
<td>Senior representative</td>
<td>2017</td>
<td>Germany / Europe</td>
</tr>
<tr>
<td>Anonymous</td>
<td>Investment company</td>
<td>Expert on corporate carbon emissions</td>
<td>2017</td>
<td>USA</td>
</tr>
<tr>
<td>Anonymous</td>
<td>Investment company</td>
<td>Expert on corporate carbon emissions</td>
<td>2017</td>
<td>USA</td>
</tr>
<tr>
<td>Anonymous</td>
<td>Investment company</td>
<td>Expert on corporate carbon emissions</td>
<td>2017</td>
<td>Denmark</td>
</tr>
<tr>
<td>Anonymous</td>
<td>Major sustainability consultancy</td>
<td>Senior representative</td>
<td>2017</td>
<td>Western Europe and Americas</td>
</tr>
<tr>
<td>Anonymous</td>
<td>Portland Cement Association</td>
<td>Staff member</td>
<td>2017</td>
<td>USA</td>
</tr>
<tr>
<td>Mark Goedkoop</td>
<td>PRé</td>
<td>Founder</td>
<td>2017</td>
<td>Netherlands / Global</td>
</tr>
<tr>
<td>Joep Meijer</td>
<td>Right Environment</td>
<td>President</td>
<td>2017</td>
<td>USA / Europe</td>
</tr>
<tr>
<td>Anonymous</td>
<td>Steel company</td>
<td>Manager</td>
<td>2016</td>
<td>UK</td>
</tr>
</tbody>
</table>
4. Methodology

<table>
<thead>
<tr>
<th>Interviewees</th>
<th>Organisation</th>
<th>Position</th>
<th>Year</th>
<th>Region</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anonymous</td>
<td>Steel company Researcher</td>
<td>2016</td>
<td>France</td>
<td></td>
</tr>
<tr>
<td>Anonymous</td>
<td>Construction Staff member</td>
<td>2017</td>
<td>UK</td>
<td></td>
</tr>
<tr>
<td>Jane Anderson</td>
<td>Thinkstep, independent Consultant with</td>
<td>2017</td>
<td>UK</td>
<td></td>
</tr>
<tr>
<td>Anonymous</td>
<td>UCL Sustainable building expert</td>
<td>2016</td>
<td>UK</td>
<td></td>
</tr>
<tr>
<td>Anonymous</td>
<td>UCL Sustainable building expert</td>
<td>2016</td>
<td>UK</td>
<td></td>
</tr>
<tr>
<td>Anonymous</td>
<td>University Professor and expert on sustainable buildings</td>
<td>2016</td>
<td>Sweden</td>
<td></td>
</tr>
<tr>
<td>Anonymous</td>
<td>University of Cambridge Academic cement expert</td>
<td>2016</td>
<td>UK</td>
<td></td>
</tr>
<tr>
<td>Anonymous</td>
<td>University of Cambridge Academic steel expert</td>
<td>2016</td>
<td>UK</td>
<td></td>
</tr>
<tr>
<td>Anonymous</td>
<td>USGBC Senior advocacy and policy expert</td>
<td>2017</td>
<td>USA</td>
<td></td>
</tr>
<tr>
<td>Anonymous</td>
<td>USGBC Technical expert</td>
<td>2017</td>
<td>USA</td>
<td></td>
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</tbody>
</table>

Not all of the interview results are directly referenced in the text but all of them have helped to inform my thinking on the subject.
4.7. Discussion and conclusion

The multi-method approach pursued here has the advantage that it can shine the light on different aspects of interrelated yet distinct phenomena, which helps in elucidating a hitherto largely unexplored ensemble of processes that have the potential to become crucial building blocks in the development of the global climate change regime complex.

The limitations of this approach, however, become manifest in the necessary brevity of each individual chapter – all of which could be made subject to a book-length examination. Correspondingly, a greater focus on any one method could certainly also lead to the generation of more in-depth and systematic evidence.

Yet, the significance of the causal linkages explored and evaluated in the different chapters can only be fully grasped by appreciating them as part of a greater, multi-facetted process. The contribution of this thesis is to bring these different parts together, to allow a comprehensive understanding of the overall process, and to draw preliminary conclusions permitting to re-evaluate the contributions of a range of policies and initiatives to the global climate change regime complex.

Bearing in mind the potential for EPDs and PCFs to close the consumption gap in climate policy, the following chapters adopt an informational perspective to identify the development of institutions central to the demand and supply of EPDs/PCFs as well as of the standards and information they are composed of.

The first two empirical chapters focus on responses to the availability of EPDs and PCFs and processes that generate further demand for them. Chapter 5 develops a theory explaining which actors can be mobilised in support of different embodied emissions policies, and then tests it on the basis of an in-depth policy field study and a network analysis. Chapter 6 uses an internationally cross-comparative case study to show how energy efficiency policy in the buildings sector has helped to put demands for the disclosure of emissions embodied in building materials more firmly on the agenda.

Chapter 7 provides more context information on the emergence of the EPD regime and argues that standards, data availability and quality are all important conditions for legitimate EPD-based policies. That chapter stakes out the relevance of the subsequent empirical chapters, which focus on the drivers for the availability of the environmental data needed for quality EPDs.

Chapter 8 focuses on the informational push for sectoral EPDs. It estab-
4. Methodology

Establishes a substantial temporal overlap between sectoral information exchange in response to regulatory processes and the release of sectoral LCA information. It then takes the case of the cement sector to trace processes leading from actual or anticipated policies, over sectoral information exchange to the release of sectoral LCA and EPD data. It draws on multi-method mix comprising document analysis, semi-structured interviews, and quantitative text analysis in the form of dictionary methods and topic modelling.

Chapter 9 advances propositions on spillover mechanisms from production-based environmental monitoring and reporting to the disclosure of the environmental impacts associated with a product. That chapter first draws on CDP survey results to analyse the impacts of the institutional environment on the firm level. It then uses interviews, literature and social network data to analyse how changes at the firm level may affect their capacities to produce quality EPDs and PCFs.

Chapter 10 uses evidence in the form of interviews, literature and quantitative text analysis of the CDP survey to establish links between energy efficiency inducing policy and the diffusion of technologies that assist in creating more finely-grained PCFs and EPDs.

Chapter 11 examines the links between production-based monitoring and reporting and the availability of secondary data in LCA databases. The chapter first investigates how diverse environmental policies and initiatives have contributed towards the public availability of data. The chapter then draws on interviews to better understand how those who compile LCIs can use available data to elicit more data from producers.

The discussion in Chapter 12 then takes up the different strands from the empirical chapters and spells out their joint implications.
5. New coalitions for tackling the problem of embodied emissions

The possibility for new, information-intensive, policy instruments to address the greenhouse gas emissions embodied in products has brought about the emergence of new lobbying coalitions. Transcending prior, more disparate, framings of the environmental qualities of their goods and services, businesses can now rally behind the common framing of ‘low embodied emissions’.

Due to their potential for filling major gaps in climate policy, it becomes important to better understand the political economy of policies addressing embodied emissions. Who can be mobilised in their support? How do variations in policy design affect who can be mobilised as supporters?

This chapter first develops a theory explaining how different policy designs affect which actors can be mobilised in support of embodied emissions policies, and then tests it on the basis of an in-depth policy field study and a network analysis.
5. New coalitions for tackling the problem of embodied emissions

5.1. The potential for EPDs and PCFs to mitigate carbon leakage

EPDs and PCFs have the potential to become important elements of consumption-based approaches to climate change (on consumption-based approaches see e.g. Dauvergne 2010; Davis and Caldeira 2010; Jakob et al. 2014; Neuhoff et al. 2016). They are a promising way to make the carbon content of products transparent, and to serve as an informational basis for further climate policy. So far, EPDs have been proposed as the basis for policies targeted at different points in the value chain: At the level of intermediate products they compare products of the same class to each other, while at the level of final products they compare the relative overall carbon efficiency of the final product, regardless of the specific composition of intermediate products it is made of.

In October 2017 the governor of California approved the Buy Clean California Act, a measure against carbon leakage, which foresees that from 2019 the state should only procure a range of building materials if it can be shown by means of EPDs that they are within the levels of a maximum acceptable global warming potential. The bill affects procurements of carbon steel rebar, flat glass, mineral wool board insulation, and structural steel (LegiScan 2017; Lyubich, Shapiro, and Walker 2018, 8). The Buy Clean California Act is unique in that it is the first time a US State seeks to reduce the emissions embodied in some of the goods it imports. Californian producers had already been exposed to carbon pricing in the form of a cap-and-trade system, which provided incentives for supporting preferential treatment for ‘clean’ products, as Californian products would be likely to fulfil that criterion (Hausfather 2017).

Whereas the BCCA targets intermediate products, European actors voice demands for targeting final products. In Germany, the UK and at the European level various actors have started to advocate for the inclusion of embodied emissions performance in mandatory building standards, arguing that EPDs can help to perform the necessary calculations.¹ Such standards target buildings as final products, whose relative carbon efficiency would be calculated with a LCA that takes both operational and embodied emissions into account. Apart from minimum life cycle carbon efficiency standards combining embodied, oper-

¹Table A.2 of the Appendix provides an overview of actors advocating for a greater role for embodied emissions.
ational emissions and perhaps post-use emissions, building LCAs could also be drawn upon for tax incentives (Lehne and Preston 2018, 58).2

5.2. Theoretical framework and propositions

More information can enable new environmental policies (Esty 2004). Information on life cycle environmental impacts allows different products to be made commensurable in terms of environmental impacts, and to base policy on the comparisons that are enabled by commensuration.

As policies can have both redistributive as well as cognitive, or interpretive, effects, they can shape interest groups, just as interest groups shape policies (Pierson 1993, 598/610). Latent, potentially shared interests may only manifest themselves once specific policies, which benefit one set of actors at the expense of another, become feasible. Thus, initiatives that contribute towards capacity-building, by helping to make the greenhouse gas emissions of different products commensurable, can have ripple effects on the conditions for coalition building (on the importance of these mechanisms in climate politics see Bernstein and Hoffmann 2018).

In order to work out how information might affect political divisions one needs to be attentive to how it can affect the feasibility of regulation, i.e. how the feasibility of regulation mediates the effect of information on political divisions. By making the environmental impacts of different products commensurable – be it at the level of the building material, the building element or the building itself – policies based on LCA can transcend specific materials or technologies and, therefore, garner the support of heterogenous coalitions of product and service providers, who would, in the absence of such a more universal policy, seek to advance more particular interests.

Framing the qualities of products or services in terms of embodied emissions can provide an alternative to other sustainability framings and thus allows for the re-aggregation of interest groups behind a common framing. The way in which such a re-aggregation occurs should depend on the specific characteristics of the policy advocated. Some policies will lead to inter-sectoral and other to intra-sectoral competition over which product has lower embodied emissions.

While the Californian approach promotes intra-material competition over better carbon performance, the whole building approach can also promote inter-

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2Interview with DGNB.
5. New coalitions for tackling the problem of embodied emissions

material competition. From this, two interrelated propositions can be deduced: policies that have intra-sectoral competitive benefits to producers of goods that are relatively low carbon compared to other products within the same materials category can mobilise the support of producers of relatively low carbon *products*. In contrast, policies that have inter-sectoral competitive benefits will tend to mobilise the support of producers of *materials* that are relatively low carbon compared to other materials, or that, at least, have a greater decarbonisation potential than rival materials. In addition, a whole-building standard approach also leaves more opportunities to knowledge or labour intensive service providers who can optimise the carbon footprint of buildings.

I formalise this in the form of the following proposition, as well as with sub-propositions which specify how pathways, or sequences, vary with different policy designs:

**Proposition 1 (P1)** *Information on product life cycle emissions facilitates relatively low carbon businesses to re-aggregate behind the low embodied emissions framing*

**Proposition 1a (P1a)** *Information on product life cycle emissions enables downstream standards targeting embodied emissions*

**Proposition 1b (P1b)** *Downstream standards targeting embodied emissions have inter-industry distributional effects*

**Proposition 1c (P1c)** *Inter-industry distributional effects mobilise producers of more carbon-efficient materials and services*

**Proposition 1d (P1d)** *In the presence of inter-industry distributional effects producers of more carbon-efficient materials and services re-aggregate behind the low embodied emissions framing*

**Proposition 1e (P1e)** *Information on product life cycle emissions enables procurement benchmarks for intermediate products targeting embodied emissions*

**Proposition 1f (P1f)** *Procurement benchmarks for intermediate products targeting embodied emissions have intra-industry distributional effects*

**Proposition 1g (P1g)** *Intra-industry distributional effects mobilise producers of more carbon-efficient products within the benchmarked category*
5.3. How different sectors can rally behind the banner of embodied emissions

**Proposition 1h (P1h)** *In the presence of intra-industry distributional effects producers of more carbon-efficient products within the benchmarked category re-aggregate behind the low embodied emissions framing*

Figure 5.1 shows sub-propositions specifying the different pathways for information to affect the shaping of coalitions, depending on the policy design

5.3. How different sectors can rally behind the banner of embodied emissions

Rather than relying on scientific measurements of the environmental impacts of building materials, the 2009 version of the dominant green building certification scheme in the USA, LEED, still relied on non-measurement proxies for the environmental impacts of building materials, such as materials that were *reused, regional, recycled, or renewable* (U.S. Green Building Council, n.d.b, 55–59). A 2014 version of the British green building certification scheme BREEAM also allowed the provision of credits for the use of *recycled* or *re-used* materials (BRE Global 2014).

Where LCA is available, one could use the criterion of *embodied emissions* as an alternative or complement to non-measurement proxies. By making different materials comparable, now renewable materials such as wood, and recycled ones, such as low carbon cement, can unite behind the common banner of embodied emissions, rather than behind separate framings, where, for example, steel and conventional concrete would also be able to rally behind the banner of recyclability.

Prior framings of the environmental advantage of the different materials would have been ‘renewable’ in the case of wood, ‘natural’ in the case of clay, ‘recyclable’ and ‘re-use’ in the case of steel, and ‘recycled’ in the case of low carbon cements and concrete. However, ‘recyclable’ and ‘recycled’ are also potentially attributes of higher carbon concrete and steel, ‘natural’ and ‘renewable’ are attributes of wood pellets for heating (see Figure 5.2).

In terms of its properties for mobilising stakeholders, standards taking embodied emissions into account allow novel alliances to be forged among suppliers of different materials and also between suppliers and service providers. As these

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3Or embodied environmental impacts more generally, which, however, would be less commensurable.
Figure 5.1.: Propositions on the sequences of coalition shaping effects of product level life cycle emissions information
standards can be technology- and material-neutral, the coalitions supporting them do not need to be aligned via a preference for a certain material, type of construction or prior environmental framing. It suffices that they are united by a preference for the incorporation of embodied emissions into standards.

As embodied emissions become measurable and comparable, a new embodied emissions framing allows actors hitherto fragmented into different camps of environmental framings to rally behind one banner – it enables a re-aggregation of interest group identities. Different actors who, in the past, have emphasised different framings, such as support for wood or renewable materials or ‘natural materials’, now lobby jointly for the regulation of embodied emissions in the buildings sector. This does not only include material suppliers but also experts in sustainable construction and those actors, whose business it is to generate carbon commensurability, such as database and software providers. This shows that information-based commensuration processes can enable the articulation of new coalitions.

Figure 5.2 shows examples of sustainability qualities that have been claimed for different materials. Appendix, Section A.4 Table A.1 provides the sources of these claims.

5.4. Network analysis

By conducting a network analysis, one can test propositions P1d and P1h, which specify how variations in the inter- and intra-sectoral distributive effects of embodied emissions policy proposals correspond to differences in the composition of lobbying coalitions.

Figure 5.3 shows the joint network of embodied emissions advocates across Germany, the UK and the USA. The network graph shows that wood interests are strongly associated with the UK and German embodied emissions advocacy networks, whereas they seem to be absent in the case of the USA. When delving further into the makeup of three important actors that represent the advocacy for embodied emissions policies in the respective countries, it becomes apparent that in the USA the Buy Clean California coalition shows the presence of concrete and steel interests, including trade unions, and the absence of wood, hemp and clay interests, whereas in the UK Association for Sustainable Building Products (ASBP) and the predominantly germanophone Natureplus association wood, hemp and clay interests are dominant (see Appendix, Section A.7, Figures A.5,
5. New coalitions for tackling the problem of embodied emissions

Figure 5.2: Sustainability framings of materials
In the USA the more carbon efficient electric arc furnaces (EAFs) for steel recycling account for 61% of steel production, in the EU for 41%, whereas in China only for 10% (Smil 2014, 59). This could make any policy based on benchmarking the carbon efficiency of steel very attractive for US and EU EAF steel producers. This helps to explain why parts of the US steel industry and unions could be mobilised in favour of carbon benchmarks for procurement.\(^4\)

The steel lobbying for the BCCA is mirrored by the European steel trade association Eurofer’s support for a carbon inclusion mechanism that would have required importers into the European market to purchase EU ETS emission permits (Simon 2010) and steel giant ArcelorMittal’s intervention in favour of a European carbon border tax (Mittal 2017).

Embodied emissions, enabled by information provision, is a new banner behind which different groups, such as low-carbon cement, renewable building materials suppliers, building consultants and progressive developers, can rally. In doing so, other group identities may be weakened: some German construction wood interests parted ways with wood-as-fuel interests. Before, these were linked via their identity as ‘renewables’ (Informationsdienst Holz 2016).\(^5\)

While explicitly not speaking in the name of their companies, experts from large multinational developers and engineering consultancies like Skanska, at some point considered the world’s 5th biggest construction company (Phillips 2015), and Arup have participated in initiatives that advocated for a greater role of embodied emissions in construction. As the conceptual and planning branch of construction, they are not bound to specific building materials and their relatively high degree of sophistication may become appreciated as an asset if there are policy drivers for more innovation in the construction industry. If we can interpret this as ‘lobbying’, this would imply that not only low-carbon

\(^4\)Note, however, that the same would not hold for downstream building standards on embodied emissions, which would probably put steel, except re-usable one, at a disadvantage.

\(^5\)Various actors subscribe to the idea that the cascading use of wood, which implies that it is only burned for its energy-use after at least one other ‘higher value’ use-stage, increases it contributions to a low carbon economy, as it thus can help to provide alternative construction materials, thereby avoiding the embodied emissions associated with conventional materials (Bundesamt für Energie BFE 2010, 15; Klima-Allianz Schweiz 2016, 12f.). Crucially, support for the argument that wood can help to cut emissions by substituting high carbon materials (such as cement, steel and plastics) benefits the construction wood sector over the wood-as-fuel sector in the political-economic competition between the use of biomass as an energy carrier and as a material (on this competition see Arnold et al. 2009, 141; Fehrenbach et al. 2017, 37).
5. New coalitions for tackling the problem of embodied emissions

Figure 5.3: Major part of the transatlantic embodied emissions advocacy network

- German wood
- British-Germanophone sustainable building
- Carlton Leadership Forum (North America)
- British sustainable building
- Buy Clean California
- German wood periphery
- British wood
- German sustainable building and ENGOs
5.5. Methodology

5.5.1. Network analysis

An in-depth study\footnote{In the Appendix, Section A.5 provides more information on building materials and Section A.6 on embodied emissions advocacy networks.} of the \emph{embodied emissions in buildings} policy field in Germany, the UK, and the USA yielded a number of actors that advocate for a greater role for embodied emissions in policy-making.

Table 5.2 shows the entities that were classified as targets in the embodied emissions network.\footnote{Sometimes these are documents rather than organisations.} This consists of two layers. On the one hand, those entities that are directly associated with advocacy or technical guidelines for the con-

<table>
<thead>
<tr>
<th>Name</th>
<th>Outdegrees</th>
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<tbody>
<tr>
<td>Arup</td>
<td>8</td>
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<tr>
<td>Skanska</td>
<td>7</td>
</tr>
<tr>
<td>Circular Ecology</td>
<td>4</td>
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<tr>
<td>thinkstep</td>
<td>4</td>
</tr>
<tr>
<td>British Woodworking Federation</td>
<td>3</td>
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<tr>
<td>UCL</td>
<td>3</td>
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<tr>
<td>Atkins</td>
<td>3</td>
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<tr>
<td>Davis Langdon / AECOM</td>
<td>3</td>
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<tr>
<td>Timber Trade Federation</td>
<td>3</td>
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<tr>
<td>Laing O’Rourke</td>
<td>3</td>
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<tr>
<td>UKGBC</td>
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</tbody>
</table>
5. New coalitions for tackling the problem of embodied emissions

Consideration of embodied emissions (first order). On the other hand, some of the organisations that are affiliated with the first, for example as sponsors or members (second order). Network connections are “realist”, i.e. based on association between organisations. This is objective, in so far as actors self-identify their associations (Laumann, Marsden, and Prensky 1992, 65). However, the inclusion of the set of organisations and the extent to which one pierces behind some entities’ layers, and where one stops to include additional layers, is somewhat subjective. Sometimes, it appeared, meaningful connections could not be identified without going back some layers, while at other times the inclusion of more actors would unduly dilute the network and make it useless for the purposes of analysis. Section A.6 of the Appendix provides detailed qualitative information on these networks, as well as reasons for the inclusion or exclusion of specific actors.

Where the network nodes were associations, their member organisations and other associates, such as sponsors, were collected by analysing information on their affiliations from their websites in 2017 and 2018. This resulted in a network with 2,174 nodes and 2,249 edges. After filtering out all nodes that have less than two connections to other nodes, there were 88 nodes and 161 edges left.

The Walktrap algorithm served to cluster the network into different communities (Harenberg et al. 2014, 429), as indicated by the different colours in Figure 5.3.

Table 5.2.: Entities as targets in embodied emissions network

<table>
<thead>
<tr>
<th>Entities</th>
<th>Order</th>
</tr>
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<tbody>
<tr>
<td>Alliance for Sustainable Building Products (ASBP)</td>
<td>1</td>
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<tr>
<td>Arbeitsgemeinschaft der Rohholzverbraucher e.V.</td>
<td>2</td>
</tr>
<tr>
<td>ASBP BREEAM Consultation</td>
<td>1</td>
</tr>
<tr>
<td>Athena Sustainable Materials Institute</td>
<td>2</td>
</tr>
<tr>
<td>Building Alliance (GA)</td>
<td>1</td>
</tr>
<tr>
<td>Bundesverband der Säge- und Holzindustrie e.V.</td>
<td>2</td>
</tr>
<tr>
<td>Buy Clean California Campaign (BCC)</td>
<td>1</td>
</tr>
<tr>
<td>Carbon Leadership Forum (CLF)</td>
<td>1</td>
</tr>
<tr>
<td>Deutscher Holzwirtschaftsrat (DHWR)</td>
<td>1</td>
</tr>
<tr>
<td>Deutscher Massivholz- und Blockhausverbandes e.V.</td>
<td>2</td>
</tr>
<tr>
<td>Embodied Carbon Task Force (ECTF)</td>
<td>1</td>
</tr>
<tr>
<td>German Sustainable Building Council (DGNB)</td>
<td>1</td>
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</tbody>
</table>
5.5. Methodology

<table>
<thead>
<tr>
<th>Entities</th>
<th>Order</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gesamtverband Deutscher Holzhandel e.V.</td>
<td>2</td>
</tr>
<tr>
<td>GLA Guidance</td>
<td>1</td>
</tr>
<tr>
<td>Green Construction Board (GCB)</td>
<td>1</td>
</tr>
<tr>
<td>Hauptverband der Deutschen Holzindustrie und Kunststoffe verarbeitenden Industrie und verwandter Industrie- und Wirtschaftszweige e.V.</td>
<td>2</td>
</tr>
<tr>
<td>Innovation and Growth Team (IGT)</td>
<td>1</td>
</tr>
<tr>
<td>Natureplus</td>
<td>1</td>
</tr>
<tr>
<td>Polaris Materials</td>
<td>2</td>
</tr>
<tr>
<td>RICS Methodology</td>
<td>1</td>
</tr>
<tr>
<td>Silicon Valley Leadership Group</td>
<td>2</td>
</tr>
<tr>
<td>Sustainable Silicon Valley</td>
<td>2</td>
</tr>
<tr>
<td>Timber Accord</td>
<td>1</td>
</tr>
<tr>
<td>U.S. Concrete</td>
<td>2</td>
</tr>
<tr>
<td>Verband der Deutschen Holzwerkstoffindustrie</td>
<td>2</td>
</tr>
<tr>
<td>Verband Deutscher Papierfabriken e.V.</td>
<td>2</td>
</tr>
<tr>
<td>Verband Österreichischer Ziegelwerke</td>
<td>2</td>
</tr>
<tr>
<td>Wood for Good</td>
<td>1</td>
</tr>
<tr>
<td>Zero Carbon Non Domestic Task Group (ZCNDTG)</td>
<td>1</td>
</tr>
</tbody>
</table>

5.5.2. Material compositions analysis

For each regional case, one organisation was chosen as the most pure, typical, representative of an advocate for a specific policy. By focusing on these three main organisations and their membership, it became possible to identify the materials suppliers associated with embodied emissions advocacy. The appearance of similar actors in other organisations may then seem less accidental.

It was not always possible to cover the sheer breadth of different building products. The focus was on commonly recurring building products.

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8See the Appendix, Section A.6.2 for a detailed description of the regional cases, providing background on the choice of different representatives.
9See the Appendix, Section A.7.
5. New coalitions for tackling the problem of embodied emissions

5.6. Discussion

There is a difference in the mobilisation logics between the European and Californian approaches. In California, the strategy of specifying minimum carbon intensities for the materials in question may have allowed the emergence of a coalition of businesses representing incumbent materials, labour unions and environmental groups to push for the legislation. It is doubtful that this could have succeeded in the same way with a generalised LCA building standard. Whereas efficiency standards at the level of building products can pitch domestic against foreign interests (or state against nationwide ones), depending on relative carbon intensities, LCA assessments of buildings would also pitch materials against each other.

While the EPD-based policies most prominently advocated for in the USA and Europe have profoundly different implications for inter- and intrasectoral competition, the additional push for the diffusion of EPDs that can be expected as a result of successful implementation would improve the basis for any one of these policies. In addition, it would also improve the basis for the potential adoption of carbon import tariffs. These policies, while being backed by very different constituencies, are not mutually exclusive, and could be combined. However, it is important to be attentive to the differences between the Californian and European policies that are advocated and not infer that support for one of the policies necessarily implies support for the other.

The building of greater capabilities for EPD creation could also help to introduce embodied emissions standards in other industrial areas, such as automotive (European Political Strategy Centre 2016, 6f.) or food (Freidberg 2014; The Local 2018; Quackenbush 2018).

5.7. Conclusion

A wide range of different building material suppliers and service providers can rally behind the banner of a greater role for embodied emissions. Commensurability enables technology- and material open policies that have the potential to re-aggregate interest groups behind common demands, instead of being splintered into different groups, who would each advocate for privileges in accordance with more material-specific framings. Whereas in the absence of feasible embodied emissions policies, these actors would advocate, if at all, for policies justified
by different (if overlapping) sustainability framings, feasible embodied emissions policies allow actors to re-aggregate behind a novel common frame for policy demands.

Different embodied emissions policy designs help to muster the support of different constituents. Whereas the BCCA can muster support from the same trade unions that support President Trump’s steel tariffs (Brotherton-Bunch 2017; Lombardozi 2017, 2018; Alliance for American Manufacturing 2018), building standards that incorporate embodied emissions criteria are better suited to garner support by alternative low carbon providers and sophisticated planners and service providers, who are not bound by specific materials and who can benefit from novel challenges in construction.

The non-exclusive nature of different embodied emissions policies means that correspondingly different coalitions can be fostered either simultaneously or sequentially, with synergetic spillover effects in the form of forced diffusion of EPDs, which serve as the informational foundation of such policies.

The coalitions studied in this chapter coalesce around policies based on the availability of EPDs. The next chapter demonstrates the crucial role energy efficiency policy has played for stimulating the diffusion of EPDs. It also shows that energy efficiency policy has significantly contributed to putting embodied emissions on the agenda.
6. Energy efficiency as a catalyst for the governance of embodied emissions

Energy efficiency and carbon pricing are among the major policy approaches towards tackling the challenge of anthropogenic climate change. Both approaches suffer from severe limitations to their effectiveness: the link between increasing energy efficiency and a reduction of absolute CO$_2$ emissions is far from straightforward. Existing carbon pricing schemes fail to address the consumption of products from outside the area in which the carbon price is applied, thus not covering the emissions ‘embodied’ in products.

With both policies suffering from their own deficiencies, it is important to see how they relate to each other, and how their interaction may drive forward the evolution of the climate policy regime. Are they only complementary or alternatives or could they jointly engender novel outcomes? An informational-institutional perspective allows to see how their evolution may be linked in various ways. Here I focus on one direction such a causal link may have taken and pose the research question: How has energy efficiency policy affected the informational basis for the governance of embodied emissions?

In responding to this question, I present a novel argument, pointing out how energy efficiency policy has catalysed the growth of institutions with the potential to inform an eventual inclusion of consumption into carbon policy. I formalise the argument in the form of a series of stylised causal sequences in order to support the proposition that energy efficiency policy has indirectly helped to improve the informational basis for addressing emissions embodied in building materials.

In the next section I briefly review critical problems to the effectiveness of carbon pricing and energy efficiency policy in the fight against climate change and point out the potential of EPDs and PCFs for informing attempts at including consumption into carbon policy. Thereafter, I present the underlying
6. Energy efficiency as a catalyst for the governance of embodied emissions

theoretical framework and the stylised causal sequences. After the methodology section I demonstrate, on the basis of an international cross-comparative case study, how energy efficiency policy in the buildings sector has helped to put demands for the disclosure of emissions embodied in building materials more firmly on the agenda. I argue that such information also has the potential to support other, informationally intensive, approaches to the governance of the carbon embodied in international trade, and may thereby help to strengthen the effectiveness of carbon pricing itself.

6.1. Links between energy efficiency and carbon leakage prevention

While it is probably the overwhelming majority of climate policy pundits that is enthusiastic about energy efficiency policy (Nordhaus 2013; Stern 2015), there are good reasons to be sceptical about its contribution towards climate change mitigation, considering that increases in energy efficiency have been accompanied by greater energy use and that rebound effects may diminish the climate mitigation effects of energy efficiency policies (Herring 2006, 18f.; Helm 2012, 118f.; Sorrell 2015, 81).

Herring (2006, 18f.) insists that “the blanket statement ... that a policy of improving national energy efficiency will lead to lower national energy consumption is too simplistic and likely to prove false”. He acknowledges that “[e]nergy efficiency saves people money” but warns that “as a solution to the problem of global warming, it is fatally flawed” for in “Western Europe over the past 25 years, overall energy use has risen despite great improvements in energy efficiency”.

Helm (2012, 118) also discredits the arguments for the role of energy efficiency in climate policy, “that energy efficiency will substantially reduce general energy demand; and that there are lots of projects with positive returns”, as fatally flawed. Instead, both Helm and Herring, who otherwise strongly differ in their perspective on the role of fossil fuels and renewables, advocate a stronger emphasis on carbon pricing. Helm (2012, 119) asserts that “whatever the merits of energy efficiency policies, they will probably will not make much difference to the global emissions path, short of a technological breakthrough”.

Sorrel (2015, 81) notes that
“The common expectation of energy efficiency improvements leading to proportional reductions in energy demand is misconceived—the linkages between the two are complex and rebound effects are frequently large.”

The following then, seeks to uncover another linkage between the two, that between energy efficiency policies and the feed-forward effects it may have on energy demand via an indirect strengthening of the informational basis for consumption-based approaches to carbon policy.

The wide diffusion of EPDs could ease the administrative burden for different such consumption-based approaches. As the proliferation of EPDs in the building product sector has been particularly pronounced, the following analysis focuses on the building sector.

6.2. Theory, proposition and causal sequences

I respond to the question of how energy efficiency policy has affected the informational basis for the governance of embodied emissions by proposing sequences of mechanisms whose succession and interactions link energy efficiency policy to an improvement in the conditions for the governance of embodied emissions. My proposition here is that

**Proposition 2 (P2)** *Energy efficiency policy has indirectly helped to improve the informational basis for addressing emissions embodied in building materials*

I elaborate the underlying mechanisms in the form of a series of stylised causal sequences, based on historical institutionalism, which helps to explain change in a complex multi-actor environment. In particular I draw on three of Mahoney and Thelen’s (2009) four modal types of institutional change: displacement, layering, drift, and conversion. In addition, I draw on the typology of scaling and entrenchment as advanced by Van der Ven et al. (2017). While, empirically, the stylised causal sequences listed below do not necessarily occur in the same order, I suggest that the sequences listed later tend to depend on the earlier ones.

The second wave of energy efficiency regulations for buildings, those that are legitimised not just by energy security but also by climate concerns, establish or affirm the institution of environmentally-justified building regulations. In doing so
6. Energy efficiency as a catalyst for the governance of embodied emissions

The very success of energy efficiency policy has supported the sustainable buildings field but also exposed it to institutional drift, as greater energy efficiency tends to result in a greater relative share of embodied emissions. Organisations and experts in the sustainable buildings field need to keep ahead of generalised developments, to maintain their pioneer status, which makes this field sensitive to organisational drift. Once ‘sustainable building’ institutions are erected and their traditional field of expertise becomes more mature, they start to look out for new opportunities that can match their expertise. Retaining the same assessment procedures in the face of changing circumstances would endanger the pioneering role of ‘sustainable building’ institutions and thus their raison d’être.

Figure 6.1 shows the institutional drift of energy efficiency institutions in stylized form: as energy efficiency increases and the relative share of embodied emissions does so, too, these changing circumstances, which are due to the effect of the energy efficiency institution itself, change the impact of the institution. Green building schemes can respond to such drift by expanding the range of their assessments to include embodied emissions.

Figure 6.1.: Institutional drift of energy efficiency institutions

**Sequence 1 (S1)** *Energy efficiency has been a rationale for government to support green building certification standard setting by private actors*

The very success of energy efficiency policy has supported the sustainable buildings field but also exposed it to institutional drift, as greater energy efficiency tends to result in a greater relative share of embodied emissions. Organisations and experts in the sustainable buildings field need to keep ahead of generalised developments, to maintain their pioneer status, which makes this field sensitive to organisational drift. Once ‘sustainable building’ institutions are erected and their traditional field of expertise becomes more mature, they start to look out for new opportunities that can match their expertise. Retaining the same assessment procedures in the face of changing circumstances would endanger the pioneering role of ‘sustainable building’ institutions and thus their raison d’être.

Figure 6.1 shows the institutional drift of energy efficiency institutions in stylized form: as energy efficiency increases and the relative share of embodied emissions does so, too, these changing circumstances, which are due to the effect of the energy efficiency institution itself, change the impact of the institution. Green building schemes can respond to such drift by expanding the range of their assessments to include embodied emissions.
This can be expressed as the following sequence:

**Sequence 2 (S2)** Energy efficiency policy leads to increases in buildings’ energy efficiency, resulting in a relatively higher share of embodied emissions, which exposes the sustainable buildings field to institutional drift

Once environmentally-justified building policies and initiatives are established, advocacy for the inclusion of embodied emissions can layer onto or seek to convert existing policies and initiatives into whole-carbon ones.

Without the prior energy efficiency movement, neither the normative idea that government should have a mandate for imposing strict environmentally justified building standards, nor the epistemic infrastructure for making use phase and embodied emissions commensurable, would have been strongly established. Energy efficiency action has brought about the informational infrastructure for making operational and embodied emissions commensurable in the form of ‘whole-life emissions’. Where energy efficiency advocates demand building regulations on the basis of climate action, this norm can also be drawn upon by advocates for the consideration of embodied emissions.

**Sequence 3 (S3)** Institutional drift provides justification for working towards the inclusion of embodied emissions

Government support for green building schemes or the adaptation for their own use are instances of layering or cross-over scaling that provide green building schemes, and thus the demand for EPDs, with additional heft.\(^1\)

**Sequence 4 (S4)** Government support for private green building certification schemes scales up their impact

Green building certification schemes entrench EPDs by adopting incentives for their adoption in acts of layering or self-organised scaling, as one initiative draws upon another. Some interventions open up new possibilities for further interventions, where one intervention can draw on the output of a prior intervention.

**Sequence 5 (S5)** Private green building certification standard setters entrench EPDs by providing incentives for using them

\(^1\)It is termed cross-over scaling here, despite the state seemingly being the active side, to emphasise that the state, by lending support to or drawing upon their initiatives, magnifies the effects of non-state actor action.
6. Energy efficiency as a catalyst for the governance of embodied emissions

When one green building certification scheme after another began to include incentives for the use of products with EPDs, in an instance of modular scaling, they provided positive feedbacks, leading to entrenchment of the EPDs in the building sector. EPDs were entrenched due to positive feedbacks, which occurred when other green building certification schemes joined in, thus leading to increasing returns, which made the release of EPDs for building products producers even more attractive (on the processes of entrenchment see Bernstein and Hoffmann 2015, 28).

**Sequence 6 (S6)** Successive adoption of incentives for using EPDs by private green building certification standard setters further entrenches EPDs

Non-state actors support government action on embodied emissions via cross-over scaling: governments can layer onto green building certification schemes’ early endorsement of EPDs by constructing policies that draw on the eventually greater availability of EPDs.

**Sequence 7 (S7)** Widely available EPDs increase feasibility for government to layer embodied emissions policies on top

Figure 6.2 shows the sequences proposed above in their interplay, leading from energy efficiency to the availability of information for embodied emissions policies.

Evidence for the empirical manifestation of certain successions of sequences, and their causal linkage, would strengthen the case for the proposition that energy efficiency policy has indirectly helped to improve the informational basis for addressing emissions embodied in building materials.

6.3. Methodology

In the following I draw on the concepts outlined above to trace the historical processes (Collier, Brady, and Seawright 2010) from a concern with energy efficiency in buildings to one with embodied emissions. I focus on the cases of the USA, and here, in particular, California, as well as on the EU, in particular Germany and the UK, as these regions have seen the emergence of strong advocacy for addressing embodied emissions in the built environment. I conducted this cross-national comparison on the basis of secondary literature, document analyses and interviews. The stylised causal sequences above are the results of a
back-and-forth between engagement with theoretical approaches and empirical material.

While in the following I am going to compare a number of cases of varying geographical scopes, such a comparative analysis needs to be attentive to the fact that the green buildings field and demand for EPDs has become thoroughly transnational (see Table ??).

### 6.4. Case studies

The case studies show two very different pathways of sequences towards the manifestation of different policy demands in the cases of Germany and the UK,
6. Energy efficiency as a catalyst for the governance of embodied emissions

one the one hand, and California, on the other hand: In all three cases, the pathway $S_1 \rightarrow S_4 \rightarrow S_5 \rightarrow S_6$ can be observed, which leads to the entrenchment of EPDs. However, the pathway $S_2 \rightarrow S_3$, leading to demands for the incorporation of embodied emissions criteria into building standards, could not be observed in the case of California. Instead, political demands there focused on the difference between ‘clean’ and ‘dirty’ products, with the twist that California’s lead role in environmental policy results in its own domestic producers to be often cleaner than foreign competitors. The prior introduction of a GHG cap-and-trade scheme is likely to have contributed to improving the carbon efficiency of California’s industry. In California’s case one can observe the pathway $S_1 \rightarrow 4 \rightarrow S_5 \rightarrow S_6 \rightarrow S_7$, with the government layering embodied emissions policies on top of widely available EPDs. Interconnected by transnational business, the diffusion of EPDs in all cases should have benefited from the entrenchment of EPDs by their successive adoption by the different private building certification standards setters (S6) (see Table ??). The case of the EU is briefly addressed as a context for the German and UK cases.

6.4.1. EU

*Energy efficiency policy leads to increases in buildings’ energy efficiency, resulting in a relatively higher share of embodied emissions, which exposes the sustainable buildings field to institutional drift (Sequence 2)*: The European Union has sought to promote energy efficiency with the climate rationale in mind since at least 1993, with the passing of Directive 93/76 to limit carbon dioxide emissions by improving energy efficiency. In 2006 Directive 2002/91 on the energy performance of buildings became operational, which obliged member states to set minimum energy performance requirements, measurable in accordance with criteria stipulated in the Directive. The Directive was mainly targeted at new-builds but also included efficiency improvements for large properties undergoing renovation (Krämer 2016, 342ff.).

In 2007 the European Commission (2007, 2) announced a lead market initiative with the aim of stimulating the “emergence of markets with high economic and societal value”. ‘Sustainable construction’ was one among the six markets identified for the initial stage of the initiative. Amongst the core rationales for choosing sustainable construction as a lead market, the Commission (2007, 5) stated that
6.4. Case studies

“Buildings account for the largest share of the total EU final energy consumption (42%) and produce about 35% of all greenhouse emissions.”

The examples it provided for broader environmental concerns were also energy-related: efficient electrical appliances and heating installations.

In 2010 a revamped Directive on the energy performance of buildings not only extended and specified the requirements further, but also injected a lot of ambition, to the extent that by 2020 all new buildings are supposed to be nearly-zero energy buildings. Member states were asked to develop certification systems to measure and benchmark the energy performance of buildings. In 2012 a general energy efficiency directive was adopted, with a 20% energy savings target for 2020, asking member states to adopt individual targets (Krämer 2016, 342ff.).

The European Construction Products Regulation (CPR) (European Parliament and Council 2011) stipulates that, when available, EPDs should be used to assess the environmental impact of construction works. Amongst the “Basic Requirements for Construction Works”, it lays down that the latter must be designed and built in such a way so that, over their life cycle, they do not have an excessive impact on the climate (Annex 1, Article 3).

In July 2014 the European Commission (2014, 3) published its Communication on Resource Efficiency in the Building Sector, noting that, due to increases in the embodied greenhouse gas emissions of buildings, and their significant share of total greenhouse gas emissions, it has become important to consider the entire life cycle of a building in order to tackle the environmental impacts effectively.

Both statements clearly endorse the norm of LCAs, rather than just focusing on operational emissions. The latter statement suggests the importance of LCAs as a response to the relative growth of embodied emissions, in order to make operational and embodied emissions commensurable.

6.4.2. UK

Government support for private green building certification schemes scales up their impact (Sequence 4):

The UK Building Research Establishment (BRE) proclaims BREEAM, launched in 1990, to have been the world’s first sustainability assessment
method for buildings (Aubree, n.d.).

In 1999 BRE published a methodology for conducting LCA for building materials, known as Environmental Profiles (BRE Global, n.d.a, 9). BREEAM started to provide credits for the selection of what their *Green Guide* considered to be low impact construction materials, based on Environmental Profiles. Credits could be obtained for specifying major building elements, rather than individual products, that obtained A ratings within the Green Guide (J. Anderson et al. 2006).

Beginning in 2002 UK government departments have been required to conduct an assessment in accordance with the BREEAM green building rating scheme, or equivalent, on construction and refurbishment projects exceeding a certain value (Moss 2010; Cabinet Office 2012, 14ff.). At least since 2005 this has also applied to local authorities (Local Government Task Force Constructing Excellence 2006, 7).

**Energy efficiency has been a rationale for government to support green building certification standard setting by private actors (Sequence 1):**

In 2006 the then-chancellor of the Labour government, Gordon Brown, announced the ‘zero carbon homes’ policy, with the aim of effectively providing for all energy needed for heating, hot water, lighting and ventilation either by generating energy by the building itself or via offsetting mechanisms (Zero Carbon Hub 2012). A consultation document laid out the three main policy levers by which ‘zero carbon’ emissions in new housing should be achieved

- the Code for Sustainable Homes (CSH),
- the Building Regulations, and
- the planning system (Ares 2016, 4).

The CSH, created by BRE but owned by the UK government, was a voluntary set of standards for assessing new homes (Department for Communities and Local Government 2010a; BRE Global 2018). Its highest level required ‘zero carbon’ emissions (Ares 2016, 4). From 2007/08 until 2015, in England, Wales, and Northern Ireland it became mandatory for publicly funded housing to achieve a high rating according to the CSH. Between 2008 and 2010, in England it became also mandatory for sellers of new private housing to provide buyers either with a CSH certificate or a certificate acknowledging that they had not undergone
the rating process (Designing Buildings 2017; BRE, n.d.). Here one can clearly see how a more comprehensive environmental certification scheme served as a pillar for improving carbon efficiency, highlighting the importance of rescaling across issue areas.

Continued commitments to the zero carbon policy under the Labour and Liberal-Conservative governments were finally abandoned by the Conservative government (HM Government 2011b, 210f.; Archer 2015; HM Treasury 2015, 46).

Energy efficiency policy leads to increases in buildings’ energy efficiency, resulting in a relatively higher share of embodied emissions, which exposes the sustainable buildings field to institutional drift (Sequence 2):

In 2011 Allwood and Cullen (2011, 14/28) forecasted, “based on the UK’s Part L Building Regulation targets and the Zero Carbon targets for new buildings”, that between 2015 and 2020 embodied emissions would have become more significant than operational ones. This shows the importance of energy efficiency for the saliency of embodied emissions.

A model projection by the Green Construction Board (GBC) (2013, 90) suggests that ‘capital carbon’, which, in addition to embodied emissions also takes the eventual demolition of a building into account, would rise from 18% of the built environment’s emissions in 2010 to 40% in 2050. The GBC (2013, 4/11) notes trade-offs between operational and capital carbon, with energy efficiency measures possibly leading to higher capital carbon expenditure. Here, we can see how the GBC frames the issue of embodied emissions as gaining in saliency as a direct result of the increase in energy efficiency efforts.

Private green building certification standard setters entrench EPDs by providing incentives for using them (Sequence 5): The CSH limited the amount of products one could use with the lowest Green Guide rating (Department for Communities and Local Government 2010a, 95), a precursor for the use of EPDs in BREEAM. This provided an important incentive for producers to obtain LCAs for their products.

Institutional drift provides justification for working towards the inclusion of embodied emissions (Sequence 3): In the UK demands for

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2 Interview with Jane Anderson.
3 This is in tune with lobbying against ambitious EU energy efficiency targets (Energiewende Team 2017; Johnston 2017.)
4 Interview with Jane Anderson.
policy to address embodied emissions in the buildings sector often focused on the aims and consequences of the zero carbon homes policy. Table 6.1 shows UK actors demanding that embodied emissions be addressed.\(^5\)

<table>
<thead>
<tr>
<th>Organisation</th>
<th>Type</th>
<th>Position on embodied emissions</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Innovation and Growth Team</td>
<td>Industry expert group</td>
<td>as public sector procurement criterion – first stage towards regulation of embodied carbon</td>
<td>2010</td>
</tr>
<tr>
<td>Wood for Good</td>
<td>Industry group</td>
<td>government should provide a consistent methodology for the assessment of embodied carbon and life cycle assessment in buildings</td>
<td>2011</td>
</tr>
<tr>
<td>Green Construction Board</td>
<td>Government-industry body</td>
<td>address embodied emissions in tandem with operational ones</td>
<td>2013</td>
</tr>
</tbody>
</table>

6.4. Case studies

<table>
<thead>
<tr>
<th>Organisation</th>
<th>Type</th>
<th>Position on embodied emissions</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timber Accord</td>
<td>Industry group</td>
<td>assessment of whole-life carbon for all buildings</td>
<td>2014</td>
</tr>
<tr>
<td>UK Green Building Council Zero Carbon Non Domestic Task Group</td>
<td>Green building council</td>
<td>embodied carbon regulations for buildings not before 2022</td>
<td>2014</td>
</tr>
<tr>
<td>Embodied Carbon Industry Task Force</td>
<td>Ad-hoc industry expert group</td>
<td>as criterion towards compliance with government ‘zero carbon’ home standard and building regulations should be developed to eventually include whole-life carbon emissions for ambitious targets for embodied emissions reductions in buildings</td>
<td>2014</td>
</tr>
<tr>
<td>Alliance for Sustainable Building Products</td>
<td>Trade association</td>
<td></td>
<td>2014</td>
</tr>
</tbody>
</table>
6. Energy efficiency as a catalyst for the governance of embodied emissions

<table>
<thead>
<tr>
<th>Organisation</th>
<th>Type</th>
<th>Position on embodied emissions</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel Construction Institute</td>
<td>Industry think tank</td>
<td>inclusion of embodied emissions in building regulations would be beneficial for steel re-use and recycling (not direct advocacy)</td>
<td>2016</td>
</tr>
<tr>
<td>UK Green Building Council</td>
<td>Green building council</td>
<td>for mainstreaming embodied carbon issue in building sector and seeks to encourage embodied carbon assessment in public sector planning and procurement</td>
<td>2017</td>
</tr>
</tbody>
</table>

6.4.3. Germany

The German Federal Government responded to the 1973 oil crisis with the Energy Saving Law of 1976, which formed the basis for the first Heat Saving Ordinance in 1977. The ordinance was revamped in 1982 and 1995 and in 2002 superseded by the Energy Saving Ordinance (EnEv)(Bundesinstitut für Bau-, Stadt-, und Raumforschung 2013). In 1996 the German development bank KfW launched the ‘CO₂-Minderungsprogramm’ (CO₂ Minimisation Programme), and
in 2001 the Gebäudesanierungsprogramm (CO₂ Building Rehabilitation Programme, CBRP), providing subsidised loans and grants for improving the energy efficiency of the building stock. Next to the climate mission, the economic stimulus that the programme provided to the construction industry also made it popular (Rosenow 2013, 219ff.). The EnEv revision of 2007 introduced an Energy Passport for buildings (Bündnis Energieausweis 2013, 8). Zero carbon homes are a stated aim of the German Energiewende (Hake et al. 2015). Towards this aim the EnEv has seen successive reforms, tightening energy efficiency requirements for buildings (Rosenow 2013).

**Private green building certification standard setters entrench EPDs by providing incentives for using them (Sequence 5):** In 2007 16 different organisations initiated the German Sustainable Building Council (Deutsche Gesellschaft für Nachhaltiges Bauen) (DGNB), which handed out the first building certificates in 2009 (Baulinks 2012). The founding members of DGNB wanted to create an LCA-based sustainable building certification system from the start, which implied the consideration of embodied emissions. Of the 16 initiating members at least two were already heavily invested in LCA: Thinkstep and its academic partner, the Department for Life Cycle Engineering (GaBi) at the University of Stuttgart (2018). The next year the Institut Bauen und Umwelt (IBU), who would become the dominant publisher of EPDs in accordance with EN 15804, was among the 121 founding members (German Sustainable Building Council 2017, 27).

DGNB and its government offspring BNB (see below) go further than just rewarding the use of EPDs: they incentivise better performance in terms of embodied emissions via ‘points’. A DGNB representative claims that since DGNB started including embodied emissions as a certification criterion and rewarding the adoption of EPDs, it stimulated exponential growth in the number of EPDs on the German market. An IBU representative agreed that in Germany incentives for the use of EPDs by green building certification schemes started with DGNB and BNB, eventually creating a lot of demand.

**Energy efficiency has been a rationale for government to support**

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6While having different meanings, ‘embodied energy’ and ‘embodied carbon’ are often used interchangeably. In Germany, the concept of ‘grey energy’ (Graue Energie) is often used. Here I translate ‘graue’ to ‘embodied’.

7Interview with DGNB.

8Interview with DGNB.

9Interview with IBU.
6. Energy efficiency as a catalyst for the governance of embodied emissions

green building certification standard setting by private actors (Sequence 1) and government support for private green building certification schemes scales up their impact (Sequence 4):

In April 2010 the Federal Ministry for Transport, Construction and Urban Development (BMVBS) released a statement on the use and acceptance of assessment systems for sustainable construction. In cooperation with the DGNB, the Ministry had developed its own, publicly available, assessment systems for sustainable construction, the Evaluation System for Sustainable Construction (“Bewertungssystem Nachhaltiges Bauen”) (BNB), aimed at assessing newly built office and administrative buildings (Federal Ministry for Transport, Construction and Urban Development 2010, n.d.; Schmidt 2012; Bundesministerium des Innern, für Bau und Heimat 2018). In 2011 the system became mandatory for Federal buildings (Federal Ministry for Environment, Nature Protection, Construction and Nuclear Safety 2016, 21). By 2015 the system also encompassed schemes for school and laboratory buildings and outdoor installations, and in the following year it went beyond new buildings and also encompassed the use phase and renovations.

Ecological aspects contribute 20-22.5 % to the overall BNB assessment. Here, a LCA needs to be conducted, including, *inter alia*, global warming potential. For the calculation of the LCAs, *only* data from recognised EPDs or the database Ökobaudat may be used (Federal Ministry for Transport, Construction and Urban Development 2010, 2015).

The German Federal Government provides the Ökobaudat online database for the LCA of buildings, whose datasets have been available for download since 2009, the same year when the first DGNB certificates were handed out. In 2016 the Ökobaudat database offered generic data and product-specific data from EPDs, in conformance with DIN EN 15804s, for more than 700 different products. Next to other ecological aspects, embodied greenhouse gas emissions are explicitly addressed (Federal Ministry for Environment, Nature Protection, Construction and Nuclear Safety 2016, 26f.).

Energy efficiency was certainly not the only but surely an important motivation for the adoption of the BNB. In 2011 the BMVBS presented the BNB as a milestone on the road to sustainability, in a broadly conceived way, presenting it as part of a series among the Club of Rome’s study on the Limits to Growth (1972), the Brundtland Report (1987), the Earth Summit (1992), the establishment of the German Council for Sustainable Development, the Guidelines and
Roundtable on Sustainable Construction (both 2001), and the National Sustainability Strategy (2002). Yet, the more recent milestones, amidst which the Ministry locates the BNB, are all climate and energy-related: the 2002 EnEv, the EU lead market initiative on sustainable construction, the 2007 Integrated Climate and Energy Programme, the 2009 Renewable-Energy-Heating Law, the 2020 target for climate neutral new-builds and the 2050 target for a reduction of primary energy demand in the building sector by 80%. In addition, it includes the 2020 target of 40% and the 2050 target of 80-95% GHG emissions reductions (Bundesministerium für Verkehr 2011, 2f.).

It is certainly possible to argue that the concern with energy efficiency was not historically necessary for the adoption of the BNB, yet without such concern, and the co-benefits which can be derived from it, there would have been much less motivation for it. In contrast, without the wider concern with environmental sustainability, the quest for energy efficiency would probably not have resulted in the generation of demand for EPDs.

Energy efficiency policy leads to increases in buildings’ energy efficiency, resulting in a relatively higher share of embodied emissions, which exposes the sustainable buildings field to institutional drift (Sequence 2): In 2016 energy standards for buildings via the EnEv were further strengthened, with a 25% reduction of primary energy consumption values for new-builds (German Federal Ministry for Environment, Nature Protection, Construction and Nuclear Safety 2016). Once the DGNB analysed the new situation they realised that many buildings already had a high energy efficiency. According to their analysis a life cycle calculation for a building with a 50 year life span already suggests a 50/50 distribution of emissions between construction and use phase. A DGNB representative suggested that the inclusion of embodied energy has arrived politically, as buildings become more and more efficient, and the possibilities for an ever further increase of energy efficiency become smaller. If one continues to solely govern via the building hull, this means a neglect of the biggest part of “the cake.”

Institutional drift provides justification for working towards the inclusion of embodied emissions (Sequence 3):

In Germany demands for policy to address embodied emissions in the buildings sector focused mainly on proposals for reforming the Energy Saving Ordinance. Table 6.2 shows German actors demanding that embodied emissions be

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10 Interview with DGNB.
6. *Energy efficiency as a catalyst for the governance of embodied emissions*

addressed.\(^\text{11}\)

<table>
<thead>
<tr>
<th>Organisation</th>
<th>Type</th>
<th>Position</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hock GmbH &amp; Co. KG</td>
<td>Renewable as subsidy</td>
<td>2012</td>
<td></td>
</tr>
<tr>
<td>Bau-Fritz GmbH &amp; Co.</td>
<td>embodied</td>
<td>2012</td>
<td></td>
</tr>
<tr>
<td>Renate Künast, politician</td>
<td>much</td>
<td>2012</td>
<td></td>
</tr>
<tr>
<td>Association Trade of German party</td>
<td>a</td>
<td>2014</td>
<td></td>
</tr>
</tbody>
</table>

\(^\text{11}\) Based on Hock-Heyl (2013); Müller (2013); German Sustainable Building Council (2016); Holzbau Deutschland – Bund Deutscher Zimmermeister (2014); Deutscher Holzwirtschaftsrat (2016a); Gebäude-Allianz (2016a), p. 5; Natureplus (2017); Chamber of Architects Baden-Württemberg and German Sustainable Building Council (2016); Deutsches Energieberater-Netzwerk (2016).
procurement
in the
buildings
sector
(not clear
whether
generally
related to
embodied
emissions
or in
particular
to wood)

German Green as 2016
Sustainable building criterion
Building council towards
Council compliance
with
government
Energy
Saving
Ordinance

Deutscher Trade as part of 2016
Holzwirtschaftsrat association German
Sustainability
Strategy,
as
criterion
towards
compliance
with
government
Energy
Saving
Ordinance,
combine
6. Energy efficiency as a catalyst for the governance of embodied emissions

Energy
Saving
Ordinance
and
Renewable
Heating
Law into
CO$_2$ Saving
Ordinance

Gebäude-Allianz Industry- make EPD 2016
NGO provision
alliance obligatory
for
contractors
so that
embodied
energy can
be
assessed,
too

Chamber of Professional as 2016
Architects association criterion
Baden-Württemberg towards
compliance
with
government
Energy
Saving
Ordinance,
which
should be
further
developed
into a
carbon
oriented

166
After many of these demands were voiced, the German Federal Government released its Climate Action Plan 2050 in November 2016, which points out the need to pay attention to the potentials for building materials to contribute to...
6. Energy efficiency as a catalyst for the governance of embodied emissions

or mitigate CO$_2$ emissions (Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit 2016, 11f./40f.), suggesting that eventual incentives for an increased use of sustainable building and insulation materials should be based on LCAs of construction materials (ibid., p. 45).

In July 2016 the Chamber of Architect Baaden-Württemberg and the DGNB advocated for the transformation of the energy saving ordinance into a climate mitigation law (Chamber of Architects Baden-Württemberg and German Sustainable Building Council 2016), and in November 2016 the Germany Wood Council (DHWR) suggested to combine the EnEv and the Renewable-Heating-Law into a new CO$_2$ Saving Ordinance, which would evaluate all measures according to their greenhouse gas potential (Deutscher Holzwirtschaftsrat 2016b). This would have meant a wholesale conversion of the EnEv into a carbon efficiency ordinance.

6.4.4. USA

Energy efficiency has been a rationale for government to support green building certification standard setting by private actors (Sequence 1) and government support for private green building certification schemes scales up their impact (Sequence 4):

In 1993 the US Green Building Council (USGBC) was founded as a non-profit organisation with the intent to develop national green building standards. In 1998 it launched its Leadership in Energy and Environmental Design (LEED) building assessment and certification system (Cidell 2012, 187).

In the USA building energy codes offer various compliance paths. For example, house builders may choose to follow the International Energy Conservation Code (IECC). This code specifically allows for green building rating programs, such as LEED, as a compliance option (U.S. Department of Energy 2012).

Some federal agencies, state agencies and cities and towns and counties have adopted different kinds of LEED policies for their own buildings. Yet, in the US LEED adoption is dominated by private sector activity. Public buildings as a proportion of LEED is less than 10% per year in the USA.\textsuperscript{12}

Government plays an important role in setting incentives for LEED adoption: Public authorities provide a range of different financial and non-financial incentives for LEED certification for private developers, each with its own conditions.

\textsuperscript{12}Interview with USGBC.
6.4. Case studies

and applicability. Financial incentives might include a break on property tax or the waving or reduction of certain permitting fees. As part of their promotion of energy efficiency, governments have offered tax deduction incentives for LEED certified buildings. For example, following the US Energy Policy Act of 2005 (EPAct), LEED certified buildings could be eligible for tax deductions.\textsuperscript{13} EPAct (109th Congress Public Law 58 2005), being an “act to ensure jobs ... with secure, affordable, and reliable energy”, only tangentially concerned with climate change and containing about $6 billion in oil and gas and $9 billion on coal subsidies (Public Citizen 2005; in Mayer 2017, 261), did not seem to affirm a wider environmental justification for building regulations – yet it did provide incentives for the adoption of energy efficiency certification programmes for buildings, including LEED.

There are also non-financial incentives, for example in some cases an increase in the density of buildings may be conditional upon LEED certification. There is also fast-track permitting, which is valuable to a developer (Goulding, Goldman, and DiMarino 2008; Labrie 2015).\textsuperscript{14}

In the USA initiatives at the subnational level are of great importance (Schreurs 2008, 344). The USGBC (U.S. Green Building Council n.d.a) boasts that more than 400 municipalities and 32 states refer to LEED as a best-practice for building sustainably. Here I limit my discussion to California, whose size of economy not only competes with those of the dozen of nation states at the top of global rankings (Nichols 2017), but which also has the largest absolute count of LEED buildings (Kahn and Vaughn 2009, 7). With its progressive outlook, the ‘Golden State’ has long been in the vanguard of US environmental policy, with the ‘California effect’ having become a staple of the environmental politics literature (Vogel 1997; Perkins and Neumayer 2012).

California’s Executive Order S-20-04 mandates all state buildings to reduce energy usage by 20% and to obtain at minimum a Silver LEED rating (Vierra 2016). While S-20-04 does mention that LEED “promotes ‘high performance’ building practices; energy, water and materials conservation; environmentally preferred products and practices” (Governor of the State of California 2004), its overall emphasis is decidedly on energy efficiency and conservation, suggesting that it has been its core rationale.

\textit{Private green building certification standard setters entrench EPDs} 

\textsuperscript{13}Interview with USGBC.
\textsuperscript{14}Interview with USGBC.
by providing incentives for using them (Sequence 5): LEED 4, published in 2013, changed the framework from single attributes to a more holistic life cycle approach, using LCA as a cornerstone for assessing products and materials at product and at the building scale. Now LEED offers credits for conducting whole building LCAs when building new and for purchasing building products with EPDs (U.S. Green Building Council 2014, 21). LEED thus plays an important role in creating demand for EPDs (Gelowitz and McArthur 2016).

Among the rationales for incentivising the use of EPDs, a USGBC representatives claimed that they want to incentivise industry to provide LCA data so that building designers can use the data in their product selection. The USGBC hopes that in the long-term there will be sufficient data at the product level so that estimates of embodied environmental impacts can be combined with energy modelling to enable whole-building LCAs, which would enable to see the overall impact of a building over time.

A USGBC representative suggested that developments in energy efficiency regulations for buildings could be a potential precedent for addressing the embodied impacts of buildings.

Widely available EPDs increase feasibility for government to layer embodied emissions policies on top (Sequence 7):

In 2015 governor Brown’s Executive Order B-30-15 not only established a California greenhouse gas reduction target of 40% below 1990 levels by 2030 but also stipulated that state agencies account for climate change in their infrastructure planning and investment decisions (Governor of the State of California, n.d.). Consequently, the California High Speed Rail Authority began to require EPDs when buying steel and concrete (Kuipers 2017).

In October 2017 the governor of California approved the Buy Clean California Act (BCCA), which foresees that from 2019 the state should only procure a range of building materials if it can be shown by means of EPDs that they are within the levels of a maximum acceptable global warming potential.

In the USA energy efficiency policy has directly led to incentives for the adoption of LEED, which then began to include incentives for the purchase of EPD certified products. Public sector procurement in California was already acquainted with EPDs by the requirement to obtain LEED Silver certifications,

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15Interviews with USGBC and Joep Meijer.
16Interview with USGBC.
17Interview with USGBC.
18Interview with USGBC.
6.5. Results and discussion

as the system provides incentives for EPDs via ‘points’. As many building material producers have already been supplying or developing EPDs for LEED projects in the commercial market, the Buy Clean California Act could layer onto this existing institutionalisation of EPDs and credibly assert that EPDs should become the basis for future procurement decisions, thus providing the prospect of a further positive feedback and entrenchment.

6.5. Results and discussion

One may cast doubt upon the presence of Sequence 1 that energy efficiency has been a rationale for government to support green building certification standard setting by private actors, as this rationale may have been part of an overall environmental sustainability rationale. However, the US EPAct did not have a wider environmental mandate and the history of the BNB and the CSH was also steeped in energy efficiency considerations. The initial adoption of BREEAM may, potentially, have been less energy focused. It seems reasonable to assume that the economic gains from energy efficiency were a strong co-benefit of the green building certification schemes’ more holistic approach (E. Ostrom 2010c, 105f.). In its absence, there would have been less incentives to adopt or support such schemes.

There are important differences in the extent to which wider environmental criteria were mixed or kept separately from energy efficiency policy. In the UK materials were included earlier in sustainable housing policy than in Germany, due to the inclusion of such criteria in BREEAM and the CSH. In the US the government has been supporting materials criteria indirectly, via the provision of incentives for LEED adoption. In contrast, in Germany, energy efficiency policy has been largely decoupled from the question of sustainable building materials, except in the case of the BNB, which already had a strong overall sustainability rationale to begin with, but existing energy efficiency policy has been instrumental in supporting arguments in favour of also including embodied emissions.

In the UK the institutional drift was less strongly pronounced than in Germany, as the government had supported from early on a more holistically oriented system which went beyond operational emissions, although there were complaints that the system failed to sufficiently address embodied emissions as promised (The Alliance for Sustainable Building Products and PE International
6. Energy efficiency as a catalyst for the governance of embodied emissions

While California has also pursued ambitious energy efficiency schemes for buildings, with the goal of achieving Zero Net Energy (ZNE) for new low-rise residential buildings by 2020 and for all new commercial buildings by 2030 (The California Energy Commission 2015), I could not find much evidence for an institutional drift in the form of a systematic raising of the issue that energy efficiency leads to a significantly higher share of embodied emissions. Therefore, for California I did not include Sequence 2 that energy efficiency policy leads to increases in buildings’ energy efficiency, resulting in a relatively higher share of embodied emissions, which exposes the sustainable buildings field to institutional drift. Yet, while moving towards ZNE, there is a strong possibility for this sequence to manifest in California, and the fact that my analysis has not resulted in sufficient evidence for claiming that this sequence has already manifested does not imply that it can be conclusively ruled out.

Different climatic conditions in California, as compared to Germany and the UK, may help to account for a pathway towards demands for embodied emissions policies that did not piggy-back onto zero-carbon building policies but that targeted intermediate building materials, instead.

In the different cases we can see that private initiatives have often served to incubate standards and institutions that have then been drawn upon more directly by state actors. There are strong similarities between Germany and the UK, where both governments adapted private building certification schemes for public use in acts of cross-over scaling. In contrast, in the USA governments have been supporting the private LEED scheme via policy incentives. Both approaches can be regarded as instances of layering.

Any neat depiction of cross-over scaling or private-public layering runs the danger of oversimplification. ‘Private’ initiatives may at times be better comprehended as ‘hybrid’ ones. In Germany, the LCA competency behind the DGNB seems to have been, at least initially, largely powered by a department of the University of Stuttgart. In addition, the Federal Environment Agency (UBA) supported IBU with the establishment of its EPD programme (Institut Bauen und Umwelt 2018a). In the UK, BRE used to be a government institute before its spin-out as a private entity (UK Civil Service 2006).

The ability of private transnational regulatory organisations to form com-

19I thank Raimund Bleischwitz for this point.
20Interview with IBU.
plementary relationships with other actors has been an important factor contributing to their proliferation (Abbott, Green, and Keohane 2013, 264). The British and German sustainable building institutions differed remarkably in their openness to such complementarity: In Germany, one can observe what may be deemed *self-organised* scaling, as long as one includes the possibility for orchestrated efforts here, as the prior provision of EPDs by IBU has made it more feasible to launch an ambitious LCA-based evaluation system. In contrast, in the UK Environmental Profiles and sustainable building rating schemes were both delivered by the same organisation, which limited the space for self-organised scaling. While Britain was a pioneer with the early development of the sustainable building rating schemes BREEAM, BRE’s approach to offer building product certification and green building assessment out of the same hand led to a more idiosyncratic approach, which offered less possibilities for other organisations to enter complementary relationships. Eventually, the standardised international approach – with a separation between EPD production and sustainable building certification – prevailed, possibly due to the positive reinforcement and entrenchment provided by a better embedding in international markets. For the issue at hand, this suggests the advantages of a modular approach to institution-building, which seeks to achieve the diffusion of standards through the horizontal adoption by decentralised actors, rather than trying to scale up the activities of one organisation across countries.

Having established that there is a range of potential policy instruments that take into account embodied emissions, I argue that these approaches can help to prepare the ground for BCAs, may work complementary to them, or provide alternative mitigation measures in lieu of the successful adoption of BCAs. Figure 6.3 shows different rules that draw on EPDs, thus impacting the meaning of EPDs and the regime governing its evolution. One rule has already been *implemented* and another one has been *announced*. I suggest that there is the *potential* that border carbon adjustments could draw on EPDs.

The insights from this chapter may be transferable to the automotive sector, where a transitions towards vehicles with low or zero operational emissions would likely increase the prominence of embodied emissions, and thereby boost calls for the regulation of embodied emissions.
6. Energy efficiency as a catalyst for the governance of embodied emissions

Figure 6.3.: Processes of institutional layering around EPDs
6.6. Conclusion and policy implications

It is instructive to explore how regulation, over time, can help to work towards making market-based schemes more technically, institutionally and politically feasible. As Section 2.3 discusses, the lack of a border levelling mechanism remains a crucial barrier on the way towards the adoption of carbon pricing that was sufficiently high for tackling the challenge of climate change (Grubb, Hourcade, and Neuhoff 2014, 204). Adopting a sequential approach to policy analysis helps to re-appreciate the role of regulation, here in particularly that of the energy efficiency sort, which is sometimes presented only as a second-best approach, for instance as “an effective alternative when political constraints preclude the adoption of market-based schemes” (Stern 2015, 111).

I argue that there are ways besides the actual adoption of politically and technically challenging BCAs that may already help to prepare the grounds for the eventual adoption of such measures. Energy efficiency policy has indirectly helped to improve the political, institutional, technical and epistemological conditions for the governance of embodied emissions, which may yet help in including consumption into climate policy. It has thus catalysed the development of important elements for the governance of embodied emissions.

Where the technical and political feasibility of BCAs seems limited, actors who wish to advance the conditions for them can start below the government level which would be responsible for BCAs by supporting measures that increase demand for information on the carbon embodied in products. These options include measures to address the carbon embodied in products and services via standards, taxation incentives or procurement decisions. Policy measures targeted at buildings may directly address embodied carbon, or help to increase its relative share and thereby raise its profile. However, a shift from a pure energy efficiency approach to the governance of embodied emissions is far from guaranteed.

This chapter has shown how energy efficiency policy has helped to prepare the ground for the feasibility of the embodied emission policies that are advocated by different coalitions, as described in the previous chapter. In the UK and Germany it has also provided the institutional drift upon which embodied emissions advocates could then piggy-back onto with demands for layering or conversion of energy efficiency institutions.

Advocates for the consideration of embodied emissions in buildings argue
6. *Energy efficiency as a catalyst for the governance of embodied emissions*

that EPDs can enable the corresponding policies. However, the creation of high quality EPDs is far from trivial. The validity of EPDs as a basis for regulation, and the quality of the underlying information, have been objects of contestation. The next chapter demonstrates that data availability and quality are important preconditions for the acceptance of embodied emissions policies.
7. The importance of standards, data availability and quality

This chapter provides more context information on the emergence of the EPD regime and argues that standards, data availability and quality are all important conditions for legitimate EPD-based policies. Establishing the importance of these conditions provides the rationale for the following chapters, which attend to the sources of life cycle data on the emissions embodied in products.

Whether embodied emissions policies should be adopted is politically contested. Information plays a key role in arguments about the technical feasibility of these policies. In the following I examine some evidence for the following proposition:

**Proposition 3 (P3)** *The availability of standardised quality information on embodied emissions is an important criterion for the legitimacy of policies addressing embodied emissions*

Where the availability of quality information on embodied emissions is an object of political contestation, it strengthens the case for it being an important criterion for the legitimacy of policies.

So how important is data availability and quality for the acceptance of EPD-based policies? The following section provide background information on EPDs and their standardisation processes. Section 7.2 provides evidence of actors using limited data quality and quantity as well as the lack of standards as arguments in debates over the introduction of embodied emissions standards.

### 7.1. Government and non-state crossover: LCA and EPD standard setting

Standards are an important condition for putting information into useful, commensurable formats. Lehne and Preston (2018, 57) complain that “there are
still huge inconsistencies in the data used and the outcomes of different assessments” of embodied carbon levels. Echoing a review of the literature, Afionis et al. (2016, 14) suggest that “the standardization of product footprinting would need to be improved to move from the voluntary reporting of embodied emissions to enable the regulation of embodied performance standards”. This raises the question of which processes have so far led to a greater standardisation of product footprinting?

Carbon footprinting of products or supply chains relies on Life Cycle Analysis or Assessment (LCA) (Bolwig and Gibbon 2009, 9). LCAs typically measure the carbon intensity of products as the Global Warming Potential over the time horizon of 100 years (GWP100) measured in the reference unit, e.g. kg CO₂ equivalent (BRE Global, n.d.b).¹

In the late 1960s and early 1970s the first studies started to look at life cycle aspect of products and materials (European Environment Agency 1997, 13). Due to the oil crises of the 1970s, initially energy was given a higher priority in early life cycle studies. After the oil crises, interest in LCA continued but the field developed at a slower pace, with the focus shifting to waste and outputs (European Environment Agency 1997, 13).

At the 1992 Rio Earth Summit many participants expressed hopes that LCA would become a great tool for solving environmental problems (European Environment Agency 1997, 13), and at some point UNEP began to actively promote LCA (Kaenzig et al. 2011, 39). Figure 7.1 shows the occurrence of keywords related to LCA, EPDs and PCFs in documents on the UNEP website. UNEP’s overall annual document output has so far been steadily increasing, albeit with cyclical ups and downs. The percentage of documents which contained relevant keywords peaked in 2012, the year of the Rio+20 summit, with some smaller peaks in 2009 and 2014. When it comes to the occurrence of keywords in relation to the overall text output for a year, 2012 clearly dominates all other years.

There is no universally agreed upon LCA method, though one can see tendencies towards more convergence and consensus building. Different LCA boundary definitions will lead to different results (Bolwig and Gibbon 2009, 9). There are, however, ISO standards for LCA (Kaenzig et al. 2011, 39) and different types of environmental product labels in accordance with ISO standards: Type I labels

¹This temporary boundary condition is inherently politically charged as any time horizon will privilege certain products over others. It must necessarily tend to be out of sync with politically agreed climate targets, as these are adjusted over time, while the temporal perspective of LCA stays the same over the years.
7.1. Government and non-state crossover: LCA and EPD standard setting

Figure 7.1: Occurrence of LCA/EPD/PCF related keywords in documents on the UNEP website

- Occurrence of LCA/EPD/PCF related keywords in UNEP documents
  - N = 3421

- Occurrence of keywords per 100K words

- Number of documents

Source: Internet Archive and own calculations
7. The importance of standards, data availability and quality

are based on life cycle criteria and are awarded based on the extent to which a
product matches a certain performance level, specified by a third party. Type II
labels are based on a self-declaration by producers, e.g. regarding the percentage
of recycled content. Type III labels quantify life cycle impacts and are awarded
regardless of performance criteria (Allison and Carter 2000, 1).

In 1993 ISO established a technical committee on *environmental labelling*
and already in the following year an expert for the US delegation proposed
the idea of an EPD, comprising unweighted LCA information (Bogeskär et al.
was publicly floating the idea of Environmental Declarations, or ISO Type III

A 1997 EEA report asserts that “[l]ife cycle thinking is essential in developing
the criteria for public procurement” (European Environment Agency 1997, 11).
Professor Schmidt Bleek from the Wuppertal Institute argued that the ability
to benchmark products based on LCA was “a question that can make or break
an ecological free market” (in European Environment Agency 1997, 24).

Sweden was a strong early proponent of the elaboration of EPD standards
within ISO and in 1997 started its own, parallel, official EPD scheme, which Bo-
geskär et al. (2002, 39f.), in 2002 considered “by far the best established country
scheme in Europe, and possibly worldwide”. In 2006 the ISO 14025 standard
established the principles and procedures for developing Type III environmental
declarations and how the private programmes publishing them should operate
(International Organization for Standardization 2006).

LCA data generally, including on carbon emissions, comes in the form of primary or secondary data. Primary data captures the emissions-related activities
or even the emissions itself of specific firms or even specific installations. Primary
data consists of ‘activity data’, for example distance traveled or fuel combusted,
multiplied with an appropriate emissions factor. The emissions factor can ei-
ther be a ‘default’ one from a database, or be customised in accordance with
the company-specific processes. The influential “GHG Protocol recommends
that businesses should use custom values whenever possible” (Greenhouse Gas

Measuring or estimating carbon emissions at facility or company level is a com-
plex yet relatively straight-forward task. Clearly allocating them to products
and flows between companies is more challenging. If no direct data sharing can
be established, allocation can be done on the basis of secondary data. Secondary
data is taken from somewhere else to represent material and energy flows which have not been directly measured. Secondary data varies in the degree to which it is generic or more specifically suited to a particular case. Secondary data can be supplied by specific industry associations in the form of sectoral data or may be entirely generic. Generic data is assembled by LCA experts and supposed to represent the typical product available. Sectoral data represents the emissions intensity of products from a specific sectoral association, typically structured around regional delineations. As the carbon intensity of production varies across regions, so does the carbon intensity of products.

The separation between generic and sectoral data can be fluid, as sectoral data can inform databases that are then labelled as generic. For example, in the UK part of the Building Research Establishment (BRE) Environmental Assessment Method (BREEAM) environmental rating scheme for buildings consists of the Green Guide to Specification. The ratings of different building materials in the Guide is based on generic data of UK-supplied construction products and materials. The data “is typically derived through working with UK trade associations to generate generic models drawn together with information from many product manufacture sites” (BRE Global, n.d.c). Thus, the data is generic, yet, through collaboration with UK trade associations and manufacturers, most applicable to the UK.

If supply chain emissions can be attributed to more than one firm, this may come as a mix between firm-specific and generic or sectoral data. Ideally, there would be primary data for all the processes along a value chain, even if these are under the control of various businesses. However, as often data for the entire length of the value chain is not available, more or less representative data is used as a ‘stand-in’.

How life cycle carbon emissions are to be measured is a highly contested issue. Different material producing sectors have conflicting interests when it comes to the allocation of environmental impacts. The steel, cement and wood industries all prefer different LCA methodologies.2 Certain types of LCA modelling are good for one sector but bad for another sector. A classical discussion is about the allocation of emissions between steel and concrete: The concrete sector does not want to attribute emissions to steel slag, which can be used for lower carbon concrete, while the steel sector wants to do so, as it lowers the apparent impact

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2Interview with Gary Newman from ASBP.
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of steel.\textsuperscript{3}

The International Organization for Standardization (ISO) and the European Committee for Standardization (CEN)\textsuperscript{4} have separate standards on sustainable construction. What might seem like competition is more of a process of one organisation taking the lead and the other taking up the baton at a different time. Since 1991 CEN and ISO have an agreement in order to avoid the duplication of standardisation efforts (Vienna Agreement). Both organisations seek to take into account prior work by the other one in elaborating standards, as to maintain ‘backwards compatibility’. In this spirit, ISO has taken the lead in the elaboration of LCA and, initially, EPD standards.

In 2004 the European Commission requested further standardisation activity on EPDs for construction materials from the European Committee for Standardisation (CEN) (European Commission 2004). In 2013 CEN, having benefited from financial support from some industry sectors, made the EN 15804 standard available.\textsuperscript{5} EN 15804 “provides core product category rules (PCR) for Type III environmental declarations for any construction product and construction service” (CEN/TC 350 - Sustainability of construction works 2013).

EN 15804 was prepared by the Technical Committee (TC) CEN/TC350 on sustainability of construction works (BS EN 15804:2012+A1:2013 2014, 4). CEN TC 350 presents EN 15804 not as a competing standard for ISO 21930, which “provides the principles and requirements for type III environmental declarations (EPD) of building products.”\textsuperscript{6} In parallel to this, ISO has developed more environmental standards, with greater influence of EN 15804.

EN 15804 was prepared by the Technical Committee (TC) CEN/TC350 on sustainability of construction works (BS EN 15804:2012+A1:2013 2014, 4). CEN TC 350 presents EN 15804 not as a competing standard for ISO 21930 but as a supplement with European rules (European Committee for Standardization 2013, 5).

The European Union and the European Free Trade Association (EFTA) have officially entrusted CEN with developing and defining voluntary standards at the European level (European Committee for Standardization 2018b). Its list of 258 ‘liaison organizations’ is a ‘who is who’ of European interest groups (European

\textsuperscript{3}Interview with Mark Goedkoop from PRé.
\textsuperscript{4}Comité Européen de Normalisation.
\textsuperscript{5}Interview with IBU.
\textsuperscript{6}According to CEN TC 350, it “has been utilizing the key features of all relevant ISO standards in their drafting” (emphasis added) (European Committee for Standardization 2013, 5).
7.1. Government and non-state crossover: LCA and EPD standard setting

ISO and CEN develop standards with the explicit intention of facilitating the functioning of global markets. CEN/TC350’s business plan suggests that, by relying on the standards elaborated by the TC, it may be possible to introduce sustainability criteria in private or public procurement or building regulations without erecting barriers to trade within the European Internal Market. It promises that due to the link to ISO 21930, the same benefits would apply to the world market (European Committee for Standardization 2013, 7).

The CEN TC 350 explicitly seeks to enable the quantification of sustainability aspects over the life cycle of buildings, and anticipates that its standards may “allow industry to demonstrate compliance with emerging regulations and policies” (European Committee for Standardization 2013, 6). Another aspect of CEN TC 350’s work is to “provide guidance to industry in the communication across the supply chain” (European Committee for Standardization 2013, 6). CEN TC 350 standardisation efforts effectively aim at enabling regulations and policies to target the entire building supply chain, irrespective of the geographical origin of building materials.

EN 15804 has stronger data quality requirements than ISO 14025. ISO 14025 refers to the use of the ISO 14040 series of standards as a basis for the development of Type III environmental declarations (International Organization for Standardization, n.d.). The requirements and guidelines for LCA, as prescribed by ISO 14044:2006 (2006, 11), do not comprise requirements for the collection of product-specific data. In contrast, EN 15804 stipulates:

“As a general rule, specific data derived from specific production processes or average data derived from specific production processes shall be the first choice as a basis for calculating an EPD.” (emphasis added) (BS EN 15804:2012+A1:2013 2014, 26).

In legal terminology, the difference between ‘shall’ and ‘should’ is quite severe. In this usage, ‘shall’ clearly conveys obligation. However, the obligation is weakened by introducing ‘choice’.

The norm distinguishes between EPDs describing an average and those describing a specific product. The first “shall be calculated using representative average data of the products declared by the EPD” (BS EN 15804:2012+A1:2013 2014, 26). The
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“EPD describing a specific product shall be calculated using specific data for at least the processes the producer of the specific product has influence over. Generic data may be used for the processes the producer cannot influence e.g. processes dealing with the production of input commodities, e.g. raw material extraction or electricity generation, often referred to as upstream data” (emphasis added) (BS EN 15804:2012+A1:2013 2014, 26).

Here it becomes clear that, indeed, for the “processes the producer of the specific product has influence over” specific data shall be used. This is quite explicit in demanding specific data for specific EPDs. Compared to ISO 14025, EN 15804 significantly increase requirements for producers to provide productspecific data for EPDs.

Several countries have ratcheted up the requirements for primary data in construction material EPDs via the EN 15804 norm: France and Belgium have made compliance with EN 15804 mandatory in cases where environmental declarations are made for construction products (Herczeg et al. 2014, 53). According to the German Federal Institute for Research on Building, Urban Affairs and Spatial Development (n.d.), since September 2013 its life cycle analysis database ÖKOBAUDAT completely complies with the EN 15804 standard. All EPDs that are entered into the database need to be compliant with EN 15804; compliance solely with ISO 14025 is not sufficient (German Federal Institute for Research on Building, Urban Affairs and Spatial Development 2017, 2).

EN 15804 still allows for a degree of interpretation that has resulted in variability amongst EPD schemes across Europe (UK-GBC Zero Carbon Non Domestic Task Group 2014, 30). The ECO platform, an umbrella organisation for European EPD programmes that also works on the basis of consistency with EN 15804 (Herczeg et al. 2014, 53), has been working towards voluntary harmonisation, coordinating its activities with CEN/TC 350 (UK-GBC Zero Carbon Non Domestic Task Group 2014, 30).

Dedicated PCFs, comprising only a subset of the data provided by an EPD, emerged in the 2000s (Bolwig and Gibbon 2009). Private PCF certification schemes started to offer their expertise and methodologies to manufacturer and retailers (Bolwig and Gibbon 2009, 6). Between 2007 and 2009 companies like Groupe Casino (France), Tesco (UK) and Wal-Mart (USA) started to engage with their suppliers with the aim of being able to establish the carbon footprints for the products sold at their stores (Bolwig and Gibbon 2009, 20; Dauvergne
and Lister 2011; The Economist 2011; Knox-Hayes and Levy 2011; Van der Ven, Bernstein, and Hoffmann 2017).

The publication of the British PAS 2050 product carbon foot-printing methodology in 2008 was perhaps the most significant institutionalisation of a formal methodology dedicated to product carbon footprinting (Van der Ven, Bernstein, and Hoffmann 2017, 13f). In the same year the Council of the European Union (2008, 10) published its conclusions on the Sustainable Consumption and Production and Sustainable Industrial Policy Action Plan, in which it invited “the Commission, taking into account Member States’ experience, to start working as soon as possible on common voluntary methodologies facilitating the future establishment of carbon audits for organisations and the calculation of the carbon footprint of products”. Here, a direct association between organisational and product carbon footprints was established. In consequence, the Commission conducted two studies, one on Product Carbon Footprint methods and another one on Company GHG Emissions Reporting. In 2009 the European Commission let Gallup survey citizens from 27 EU Member States and Croatia and obtained the result that 72% of them were in favour of making it mandatory for products to carry a label indicating its carbon footprint (Bolwig and Gibbon 2009, 27f.).

Yet, official enthusiasm for a label focusing exclusively on carbon soon vanished: the European Commission reports the outcome of the study on Product Carbon Footprint as the realisation that “it is important to take into consideration all environmental impacts of products in a balanced way” (European Commission 2016). As a follow-up, the Commission initiated projects on a Product Environmental Footprint (PEF) and an Organisation Environmental Footprint (OEF) (European Commission 2016).

The European Commission (2011, 10) then went on to discuss the PEF in a range of policy documents, such as its 2011 communication on the Single Market Act, where it announced that “[i]n order to ensure that consumers receive reliable information on the environmental performance of products, [it] will propose ... an initiative on the ecological footprint of products”. In terms of its discursive positioning, this announcement clearly goes beyond the realm of mere environmental politics, but is moved towards the centre of the development of, arguably, the core driver of European integration: the single market.

In 2013 ISO released ISO/TS 14067. The standard for the communication of the carbon footprint of a product draws on LCA standards ISO 14040 and ISO 14044 for the quantification and ISO 14020, ISO 14024 and ISO 14025 on
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environmental labels and declarations (International Organization for Standardization 2013). As such, ISO standards for EPDs form the basis for more narrow PCF standards.

In ISO, standards focussed on measuring greenhouse gases are developed by the Technical Committee ISO/TC 207/SC 7. Amongst the participating members are BSI for the UK and ANSI for the USA (International Organization for Standardization 2016). The BSI had collaborated with the Carbon Trust in the development of a product carbon footprint standard. ANSI has been involved in the setting up of accreditation schemes for EPD-issuers.

Within ISO, EPDs and PCFs are at least subject to standardisation activity in the realms of LCA, GHG management and environmental labelling. Figure 7.2 shows the organisations officially registered with the corresponding technical committees (TC) (as seen in February 2018).

We can see that the European Commission (EC) is in liaison with all three committees. The liaison of the WTO with the TC on environmental labelling indicates the relevancy of this standardisation activity for international trade. The Sierra Club is also in liaison with the TC on environmental labelling, and it has been a vocal proponent for the Buy Clean California campaign, which draws on EPDs (Sierra Club California 2018a, 2018b). Prior to the PCF/EPD standardisation process, WBCSD and WRI had already developed the GHG Protocol (World Resources Institute and World Business Council for Sustainable Development 2001).

7.2. Standards and data quality and quantity as objects of contestation

In 2012, as part of a consultation process, the UNEP/SETAC Life Cycle Initiative asked the question: “What is limiting more implementation of [life cycle] approaches in your country or industry?” The number one answer was: “data” (United Nations Environment Programme and Society of Environmental Toxicology and Chemistry 2012, 51).7

A number of different actors have so far made statements that suggest the importance of standards, data availability and data quality for carbon policies

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7The echoes earlier complaints: referencing literature from the 1990s, in 2008 Reap et al. (2008, 383) noted that “[i]n general, the literature tends to agree that data for life cycle inventories is not widely available nor of high quality”.

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7.2. Standards and data quality and quantity as objects of contestation

Figure 7.2.: Organisations in liaison with ISO technical committees relevant for EPDs
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that take life cycle emissions into account.

7.2.1. UK

In 2010 the Department for Communities and Local Government (2010b, 14) had held a consultation on building regulations and reported that “… the embodied carbon impact of products .. is a complex issue, which we continue to explore … In addition, because there is ongo-
ing development work on EU standards for assessing the embodied carbon impact of products, we would not set up a national approach which would necessarily be superseded by a pan-EU methodology in a few years time. Therefore at present the Department is not minded to regulate for this.”

Here, we see the importance that is attributed to standardisation activity and the need to coordinate this across the EU.

In 2010 the Innovation and Growth Team (“IGT”), a body drawn from the UK construction industry, published its report “Low Carbon Construction” with support from the Department of Energy and Climate Change (DECC), Department for Environment, Food and Rural Affairs (Defra), and the Prince of Wales’s Corporate Leaders Group on Climate Change (CLG). The IGT (2010, 26) rec-
ommended that the public sector procurement guide, the Green Book, should be expanded with a suitable methodology for a whole-life carbon assessment, once it became available. This would have been the first stage in the regulation of embodied carbon. It would have mirrored the situation in Germany, where in the same year the government made an LCA-based sustainable building as-
se ssment available and its use became mandatory for Federal buildings in the following year.

The IGT report laments the lack of reliable data at the product level and suggests that “[c]omplex products should be measured … progressively in Environmental Product Declaration (EPD) format” (2010, 27). Once a suitable methodology is found and appropriate data is available to the necessary extent, the IGT suggests that the building regulations could be extended by moving from solely addressing the operational energy of buildings to also include whole-
life carbon (Innovation & Growth Team 2010, 28).

In its response, HM Government insisted that, first, standardised approaches, such as CEN TC 350 (see Section 7.1), for the transformation of raw data
7.2. Standards and data quality and quantity as objects of contestation

into performance data, would be needed before tools could be used to evaluate the impact of design choices on whole-life carbon emissions (HM Government 2011a, 26). Here, the availability of data, and a methodology for making sense of the data, is conceptualised as a precondition for regulating whole-life carbon emissions, and thus embodied emissions.

The potentially decisive role which EPDs may play in the future consideration of embodied emissions in building policy is suggested by a statement by the Mineral Products Association (MPA) in response to a call for evidence on sustainable construction and the Green Deal. In its statement, the MPA cautions the government to not get “ahead of the science” when addressing embodied emissions but points out that due the advent of EPDs, “the construction sector should not have to wait too long for robust embodied CO$_2$ data for the materials it uses” (Mineral Products Association 2012).

In 2014 the Embodied Carbon Task Force (2014, 9), arguing for a greater role for embodied emissions in policies addressed towards the build environment, noted that

“Government has expressed concern with respect to measurement and complexity of accounting for embodied carbon. In response Industry is acting on these challenges and is increasing its capacity to measure and manage embodied carbon”. This points to the political importance of reliable and accurate information production in order to introduce carbon benchmarking policies in a legitimate way.

In 2007 BRE and organisations from the construction and property industry launched the UK Green Building Council (UK-GBC) (BRE 2018; UK Green Building Council 2018). A 2007 UK-GBC report on “carbon reductions in new non-domestic buildings” had explicitly not considered the carbon footprint of building, yet suggested it “would present a more holistic picture of the carbon emissions associated with non-domestic buildings” (UK Green Building Council 2007, 11). Seven years later, the UK-GBC Zero Carbon Non Domestic Task Group suggested that government policy should, over time, start addressing the carbon associated with the construction of buildings (embodied carbon) (UK-GBC Zero Carbon Non Domestic Task Group 2014, 4). Its roadmap was meant to provide inspirations for government policy. The roadmap foresaw an

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8 In stark contrast to Germany and the USA, the UK’s green building council does not operate that country’s most prevalent green building certification scheme, which is BREEAM.
7. The importance of standards, data availability and quality

“increasing industry alignment on methodology and assessments techniques”, cumulating into an “[a]greed embodied CO₂ standards widely adopted across industry” around 2022. This standard, it was envisaged, would eventually feed into the inclusion of embodied energy into the definition of ‘zero carbon’ in a future beyond 2022 (ibid., p. 4). In another place, the report suggests that whole-life carbon emission should be brought into regulation at some point after 2019. It suggests that designers, contractors and manufacturers should already draw on the CEN/TC 350 standard to measure and reduce embodied carbon in order to build the knowledge and the data to incorporate embodied carbon into regulation. Government could also assist by considering embodied carbon in their promotion of building informational modelling (BIM) and by preferentially purchasing products certified with EPDs (ibid., p. 8).

The Zero Carbon Non Domestic Task Group pointed to the variability between EPDs produced to EN 15804 as the underlying reason for their belief that “embodied carbon calculations would not be reliably feasible in a regulatory environment until 2022 – 2025” (UK-GBC Zero Carbon Non Domestic Task Group 2014, 30). Here, one sees the importance that market players attribute to standardisation activity.

7.2.2. USA

The advocates for the Buy Clean California Act took the example of an existing EPD tool to argue that the EPD production process can be efficiently streamlined (Buy Clean 2017a, 3). In response, a California Construction and Industrial Materials Association representative still maintained that “… the EPD process … is a complex [one, which] requires [companies] to get into their manufacturing facility, and go through, and quantify such emissions …” (California State Assembly Standing Committee on Accountability and Administrative Review Hearing of 24 April 2017).

Unlike in Germany and the UK, Product Category Rules (PCRs), which specify how to conduct an LCA for a given product group in order to make the results comparable, are issued by the different trade association themselves. Some trade associations are resistant to rating their members, so it is hard to develop PCRs in a meaningful way.9

For the USGBC there was not yet sufficient data at the product level to

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9 Interview with USGBC.
7.3. Discussion

systematically enable whole-building LCAs.  

7.2.3. Germany

According to Danny Püschel, coordinator of the Building Alliance, many actors in the German building field talk LCAs down as being too complex. Many actors reject a stronger role for LCAs, mainly arguing based on three reasons: the costs and the complexity of LCAs and the shaky data basis on which one needs to conduct LCAs. Püschel agrees that these barriers are indeed present, and presents EPDs as a tool that can help to overcome these hurdles for an LCA, as they help to increase data quality, availability and transparency. Püschel particularly points out that the building materials producers criticise LCAs for being too expensive and complicated.  

7.3. Discussion

There is some good, if anecdotal, evidence for Proposition 3, that the availability of quality information on embodied emissions is an important criterion for the legitimacy of policies addressing embodied emissions. One can find various instances where actors argue about whether the quality of information available suffices, or whether it is too complex and costly to provide the information needed to implement policies targeting embodied emissions. Table 7.1 provides an overview of such statements (based on interviews and Innovation & Growth Team 2010, 28; Mineral Products Association 2012; Green Construction Board 2013, 5; Alliance for Sustainable Building Products n.d.; Embodied Carbon Task Force 2014, 9; UK-GBC Zero Carbon Non Domestic Task Group 2014, 30; California State Assembly Standing Committee on Accountability and Administrative Review Hearing of 24 April 2017 2017; Buy Clean 2017a, 3).

Table 7.1.: Statements of actors arguing over whether information quality suffices for basing embodied emissions policy on it

<table>
<thead>
<tr>
<th>Statement</th>
<th>Actor</th>
<th>Region</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of reliable data at the product level</td>
<td>IGT</td>
<td>UK</td>
<td>2010</td>
</tr>
</tbody>
</table>

10Interview with USGBC.
11Interview with Danny Püschel, Building Alliance.
7. The importance of standards, data availability and quality

<table>
<thead>
<tr>
<th>Statement</th>
<th>Actor</th>
<th>Region</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government should wait with regulating embodied emissions until advent of reliable product level data</td>
<td>MPA</td>
<td>UK</td>
<td>2012</td>
</tr>
<tr>
<td>Carbon performance data in the form of EPDs is required for benchmarking and target setting</td>
<td>Green Construction Board</td>
<td>UK</td>
<td>2013</td>
</tr>
<tr>
<td>Acknowledge that governments has expressed concern over complexity of accounting for embodied carbon</td>
<td>Embodied Carbon Task Force</td>
<td>UK</td>
<td>2014</td>
</tr>
<tr>
<td>Embodied carbon regulations not feasible in regulatory environment until 2022-2025 due to variability in EPDs</td>
<td>UK-GBC Zero Carbon Non Domestic Task Group</td>
<td>UK</td>
<td>2014</td>
</tr>
</tbody>
</table>
Data quality has been an issue of political contestation. Advocates for taking into account whole-life carbon emissions in building standards already have said...
7. The importance of standards, data availability and quality

that the data quality is good enough for starting to base policy on it, whereas other actors have argued that whole-life carbon emissions should be addressed over time, resting on an improving data basis.

7.4. Conclusion

The greater availability of information on buildings’ energy efficiency, as well as their embodied environmental impacts, is an important resource for the advocates of a greater role for embodied emissions in policy. By being able to argue that the information available already does or may soon suffice for implementing policies targeting embodied emissions, the framing of ‘embodied emissions’ becomes more plausible, as it is linked to a policy that seems feasible, and thus provides an important focal point for the emergence of novel coalitions across diverse interest groups.

The availability of information is crucial for the technical feasibility of embodied emissions policy and, subsequently, for its political viability. The next chapters inquire into the drivers of such information availability. First at the sectoral level, then at the firm level, and finally at those contributing to the availability of data in LCI background databases.
8. ‘We’ve got that data already’. Industry sector environmental accountability and EPDs

What have been the drivers of the diffusion of EPDs? One can distinguish between informational push factors, that have conducive effects on information supply and informational pull factors, that stimulate the demand for information. This chapter focuses on the informational push for sectoral EPDs.

Some life cycle data sets or EPDs comprise specific company data. Others comprise sectoral data or even just generic data. Sectoral life cycle data can be a quicker and easier way for companies to obtain EPDs than by producing individual ones. This is likely to be conducive to the diffusion of EPDs, although such sectoral EPDs can be criticised as being only an intermediate step towards the greater accountability offered by firm-specific data.

The following advances a set of propositions on causal mechanisms linking place-based environmental policies to the generation of sectoral data on the environmental impacts of products, which, if not entirely placeless, can at least be said to potentially span across places (on placelessness see Mol 2014, 52).

The next section provides theory and proposition, followed by a summary of materials and methods in Section 8.2. Section 8.3 first describes how the European Commission, as part of the IPPC process, enticed a range of different European industry sectors to engage in the sharing of data on the environmental impacts of production. After the proposition of two mechanisms whereby such information-sharing may have fostered the production of sectoral LCA datasets, a temporal correlation between these exchange processes and the creation or publication of LCA datasets is identified. After an introductory discussion of sectoral approaches to climate change in Section 8.4, Section 8.5 then complements the macro-level analysis of temporal overlaps between IPPC and LCA events by contributing a detailed case study of the cement sector, which responded to actual or anticipated regulation by coming up with coordinated responses. A ma-
8. ‘We’ve got that data already’. Industry sector environmental accountability and EPDs

Major part of these coordination responses consisted in intra-sectoral information sharing, which became an important contribution to the production of sectoral LCA datasets. Section 8.6 summarises and discusses the results, from which Section 8.7 derives recommendations for further research and policy-makers.

8.1. Theory and proposition

This chapter adopts a ‘new’ institutionalist framework (Kollman and Prakash 2001, 407) to argue that policies which provide incentives for the intra-industry sharing of environmentally relevant information reduce transaction costs for the creation of sectoral EPDs, and are therefore conducive to their diffusion. The gist of the argument is that policies differ in the extent to which they provide incentives for companies to share information on the environmental impact of production in sectoral organisations. Environmental policies are more likely to induce intra-sectoral information-sharing when they stipulate that the specification of more detailed parameters such as technology mandates and emissions limits emerge out of cooperative deliberations between government, industry peak organisations and, possibly, civil society, rather than fixing such parameters without much consultation, in a potentially rather adversarial mode of business-government relations (on the cross-national variation of such relations in environmental policy see Kollman and Prakash 2001). Such information sharing, in turn, reduces transaction costs for the production of sectoral EPDs. The central proposition here is that

Proposition 4 (P4) A political environment that incentivises an intra-sectoral exchange on the environmental impacts of production will be conducive to the creation of sectoral life cycle data sets

Figure 8.1 illustrates this.

8.2. Materials and methods

This chapter first establishes a substantial temporal overlap between sectoral information exchange in the context of the elaboration of best available technique reference (BREF) documents for the IPPC process and the release of sectoral LCA information. It then takes the case of the cement sector to trace processes leading from actual or anticipated policies, over sectoral information
8.3. Links between IPPC and LCA

Figure 8.1.: Proposition 4

exchange to the release of sectoral LCA and EPD data. In doing so it draws on a multi-method mix comprising document analysis, semi-structured interviews, and quantitative text analysis in the form of dictionary methods and topic modelling (Roberts, Stewart, and Tingley 2018; Welbers, Van Atteveldt, and Benoit 2017).

8.3. Links between IPPC and LCA

European Union policy processes aimed at providing a common framework for the permitting of industrial installations have significantly contributed to the generation and diffusion of information on the environmental impacts associated with the production of specific industrial outputs. Directive 96/61 concerning integrated pollution prevention and control (IPPC) became applicable for new installations in 1999 and for existing installations in 2007 (Krämer 2007, 177). Initially, 45,000 large installations were estimated to come under this directive (Krämer 2007, 178) and in an implementation report in 2010 it was reported that 50,000 installations came under the Directive (Krämer 2016, 179). Under Directive 96/61 permits for industrial installations must include emission limits.
based on best available techniques (BATs). Article 16 of the IPPC Directive (Council of the European Union 1996) states that

“The Commission shall organize an exchange of information between Member States and the industries concerned on [BATs], associated monitoring, and developments in them. Every three years the Commission shall publish the results of the exchanges of information.”

This exchange of information was to find an expression in the creation of Best Available Technique Reference Documents (BREFs), describing for each specific process the BAT. A Bureau of the Commission’s Joint Research Centre produces the BREFs, taking an exchange of information into account, which proceeds in a forum constituted by the Commission, Member States, environmental organisations and, crucially, industry sectors. In mid-2006 this process had produced 32 and by the end of 2010 35 BREFs, also for sectors covered by the EU ETS, such as iron and steel, cement and lime, pulp and paper, and glass (Krämer 2007, 180, 2016, 176f.).

What are potential mechanisms linking the IPPC with LCA? First, LCA is also an established tool for the determination of BATs (Barton, Schneider, and Jager 2002). As sectors had incentives to engage in BAT deliberations, it might have made sense for them to develop LCA capacities. This would be in tune with Berkhout and Howes (1997, 79), who, based on interviews with 90 European firms, inter alia from the aluminium, chemicals and building materials industries, during 1995 and 1996, suggest that “[r]egulation, and anticipation of regulation … [has] .. played an important role in encouraging firms to adopt life cycle approaches, even though there are few examples where extended producer responsibility is mandated in law”.

Second, as the BREF elaboration process provides incentives for coordination within sectors on the exchange of information with the Commission, it may stimulate information exchange more generally, which may be a useful institutionalisation for LCA efforts to draw upon. The IPPC process provided incentives for industry to coordinate about environmental issues in an integrated way, something which has a close structural similarity to life cycle approaches. The coming together of experts on environmental impacts of industrial production, and their information exchange, may have helped to set up or further develop the contacts and the institutional structure required for the informational exchange necessary for the creation of representative LCA data.

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8.4. Sectoral approaches to climate change

To reformulate both mechanisms more succinctly into one sub-proposition:

**Proposition 4a (P4a)** *The IPPC process facilitated LCA creation by providing incentives for industrial sectors to enter or deepen a coordinated exchange of information on the environmental impacts of production.*

What form could evidence for Proposition 4a take? For the effect of the IPPC process to be relevant, it would need to be shown that the IPPC process, or its anticipation, preceded LCA creation. There should either be some form of temporal proximity and/or one should be able to identify a process linking the IPPC process to LCA creation.

Part of these considerations can be expressed in the hypothesis that *there was a temporal overlap between the IPPC process and LCA creation, with the IPPC process or its anticipation preceding LCA creation.*

This hypothesis can be subjected to a test by looking at the temporal coincidence between BREF processes and the release of LCI data on basic materials by European or international industry associations. Indeed, there is a striking temporal coincidence between the timing of the elaboration of some EU documents on BATs and either the publication of major LCA documents by industry, or the foundation of an organisation which would later become instrumental in releasing such LCA data. One can find this kind of overlap for aluminium, cement, fertilisers, paper, plastics, refineries, and steel.\(^2\)

8.4. Sectoral approaches to climate change

Beyond the BREF process there are other incentives for companies in a sector to come together to share environmentally relevant information, with varying degrees of formal or informal connections to regulatory processes.

So-called sectoral approaches can facilitate environmental monitoring and reporting, and thus the generation of data that is crucial for sectoral or firm-\(^1\)

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1. See Appendix, Section A.11, for details on the overlap between the IPPC process and LCA releases.
2. There is an additional explanation for the proactive behaviour of the European aluminium and steel industries in terms of coming forward with LCA data. Early LCA studies were strongly concerned with packaging, and steel finds a rival in aluminium in this market segment, as in several others. *Coca Cola* sponsored the first LCA study of several different beverage containers at the Midwest Research Institute in 1969 (Hunt, Sellers, and Franklin 1992, 246). Berkhout and Howes (1997, 79) note the cross-sectoral competition between steel and aluminium, and suggest that in such a situation “firms tend to collaborate in both attacking and defending their positions”.

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specific product disclosure. Sectoral environmental approaches organise companies within an industrial sector, promising to pursue greater environmental sustainability. An early example, not specific to the climate policy debate, would be the Responsible Care programme by the chemical industry. According to Prakash (1999, 326), the chemical industry sought to employ the Responsible Care programme in order to win back public trust in the chemicals industry after the 1983 Bhopal tragedy and to show that it could responsibly regulate itself, without the need for more stringent government intervention. In the climate policy area sectoral initiatives have similar overlaps between the stated mission of improving environmental sustainability and political aims.

With the introduction of emissions trading, the IPPC directive was amended to now exclude installations under the EU ETS from the BAT requirements of the IPPC directive (Krämer 2007, 178). Emissions trading policy in the EU is thus a partial substitute for emissions limits under the IPPC directive.

In contrast to the chemicals sector, whose outputs are rather diverse, sectoral approaches in the climate policy area tend to be among more homogenous actors, thus easier to benchmark. While there is no single, overarching definition of ‘sectoral approaches’ towards climate change, a Centre for European Policy Studies (CEPS) Task Force on Sectoral Industry Approaches to Address Climate Change, chaired by the then President of the World Business Council for Sustainable Development (WBCSD), claims that all of the sectoral approaches they have identified share the following characteristics:

- Bottom-up data collection to establish performance indicators,
- enhance monitoring, reporting and verification (MRV) of emissions,
- maintenance of confidentiality, and
- share information on best practices for increase of operational efficiency and available technologies (Stigson, Egenhofer, and Fujiwara 2008, 1f. / 23f.)

That a proper fulfilment of what Stigson et al. deem characteristics for sectoral approaches is far from trivial can be illustrated by the crash in the price for emission permits in the first phase of the EU ETS, which was partly explained with problems regarding definitions for data collection, historical monitoring methodologies, and emissions verification requirements (Betz and Sato 2006, 354).
8.4. Sectoral approaches to climate change

Production-based regulation is often characterised by the asymmetry of information between government and the industry it wishes to regulate. Industry can use this asymmetry to its advantage by understating its ability to improve its environmental performance. Consequently, for Stigson et al. (2008, 30):

“There must be valid reasons for an industrial sector to reveal the full extent of its mitigation potential and its real cost.”

What motivates industry to participate in sectoral approaches? Next to ‘carrots’ in the form of technical assistance, technology transfer or sector-based GHG credits, these reasons could also consist in “threats of regulation” (Stigson, Egenhofer, and Fujiwara 2008, 24). Evidently, not even the president of the WBCSD, who is among the co-authors of the report, claims that sectoral approaches grow merely out of a care for the environment, but, jointly with his co-authors, he suggests that government threats or incentives are necessary for industrial sectors to show such initiative.

The threat of a high level of regulatory burden can help to elicit information from companies. When companies reveal information to regulators, it might enable the latter to gauge a relatively ambitious level of best practice or BATs and thus cause more costs to the industry than what they would have been with more information asymmetry in place. This could be the case because a higher level of information asymmetry may have led to more caution on part of the regulators. However, reducing risks is important for a smooth functioning of business. While not providing any meaningful information could lead to a better deal, it could also turn out to be disastrous for the industry.

Stigson et al. (2008, 44) draw explicit links between sectoral approaches and carbon markets. They (Stigson, Egenhofer, and Fujiwara 2008, 4) suggest that “[i]f sectoral performance benchmarks are based on ‘best practice’, or the [BAT] in a sector, they can be used for setting the cap” in cap-and-trade schemes and that “[s]ectoral benchmarks can also be used for allocation, at least as long as free allocation continues”. If assumptions of such best practice or BAT had been very high, this could have meant potentially negative consequences for companies in the respective sectors. By generating benchmarks themselves, they could reduce that risk.

What are the links between sectoral approaches and the availability of data for LCAs and EPDs? Due to structural similarities between sectoral approaches and sectoral EPDs, the development of sectoral approaches can reduce the trans-
action costs involved in the production of sectoral EPDs. There are important similarities between sectoral approaches and sectoral EPDs, to the extent to which one may ask whether it would not make sense to regard the latter as a subset of the first. Consider the following similarities between sectoral approaches, emissions trading schemes, and EPDs:

- Bottom-up data collection to obtain sectoral averages, and need for
- standards for monitoring and reporting,
- third party verification,
- maintenance of confidentiality, and
- to steer clear from accusations of anti-competitive behaviour (see e.g. Stigson, Egenhofer, and Fujiwara 2008, 27; U.S. Federal Trade Commission 2014).

Sectoral approaches have more in common with product-level data than firm-level data, as the benchmarking aspect is clearly related to the GHG or general environmental efficiency with which products are made. This is in stark contrast to corporate level disclosure, where environmental impacts tend to be related to economic values rather than outputs.

The proposition above, on the relation between IPPC and LCA, can be reformulated as follows:

**Proposition 4b (P4b)** *Sectoral approaches facilitate LCA creation by constituting coordinated exchanges of information on the environmental impacts of production*

Proposition 4b can be transformed into the following hypothesis: *There is a causal sequence leading from coordinated exchanges of information within the context of a sectoral approach to the generation of LCA data.*

In the following a detailed case study of the cement sector serves to gather further evidence on the causal links between sectoral approaches and the creation of sectoral EPDs.

**8.5. Cement**

The following shows how leading companies in the cement sector have sought to actively reduce their exposure to regulatory risks by fostering the sharing
of information on environmental performance, which then became instrumental for the creation of EPDs. In other cases governments charged trade associations with environmental accountability, which is likely to have reduced the transaction costs for gathering the information needed for the creation of EPDs.

The World Business Council on Sustainable Development’s Cement Sustainability Initiative (CSI) is a prime example of an industry-led sectoral approach. When Stephan and Thomas Schmidheiny’s father, Max, divided his estate in 1984, Thomas inherited cement and concrete producer Holcim and Stephan ended up with the asbestos-producing Eternit (Forbes 2017). The grave health concerns associated with asbestos had been left only insufficiently addressed for decades but at some point the scandal broke loose. Stephan Schmidheiny’s (in Serafin 2009)

“... group was heading toward bankruptcy as a consequence of the combined effects of asbestos-related problems and a major slump in construction markets.”

Learning from this challenge, Stephan Schmidheiny became a key actor in shaping the international discourse on and institutions of corporate environmental responsibility (Andonova and Mitchell 2010, 264). He founded the Business Council for Sustainable Development (Serafin 2009) and his 1992 book Changing course: a global business perspective on development and the environment (Schmidheiny 1992) has become a standard reference of the corporate environmental responsibility literature.3 Eternit would eventually become one of the founding members of the German Sustainable Building Council (2018), an important advocate for the use of EPDs.

In the late 1990s Thomas Schmidheiny was the majority shareholder and CEO of what would become the cement giant Holcim4 – then called Holderbank (in the following referred to it as ‘Holcim’). The subsidiaries of Holcim in Switzerland and Belgium were particularly good at using industrial and hazardous waste as fuel for their cement plants. One plant was originally very inefficient but, due to using waste, especially of the industrial and hazardous kind, as fuel, it had nearly zero fuel cost. In other regions there was opposition against using waste as a fuel, and bad implementations of the practice were also weighing on the reputation of the practice. Thomas Schmidheiny wanted to multiply the practice

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31910 citations on Google Scholar in December 2017.
4And, after a merger, turn into the world’s largest cement manufacturer: LafargeHolcim.
but was also aware of the risk it involved. There are many potential problems
with respect to waste as a fuel and one needs to have a very good environmental
management to reduce the risks arising from it. Holcim could perform well,
using waste as a fuel, but if others were emulating the model, without showing
the same environmental performance, it could lead to a backlash and jeopardise
the practice.5

His brother’s story is likely to have made Thomas aware of the risks health
and environmental scandals can bring to industrial enterprises. Via his brother,
he also had close connections to the Business Council for Sustainable Develop-
ment, which, after a merger with the World Industry Council for the Environ-
ment, would become the World Business Council for Sustainable Development
(WBCSD). So in order to be able to reduce the risks of using the cost saving
possibility offered by using waste as a fuel, in 1999 Holcim initiated the founding
of the CSI, under the auspices of the WBCSD, which by the year 2000 could
count about ten cement companies amongst its members. When they were con-
sidering the long-term strategic challenges to the cement sector, they identified
three core issues: waste as a fuel, CO₂ emissions and climate change, and health
and safety.6

Holcim began considering to comprehensively monitor its GHG emissions al-
ready in 1999. When Vanderborght began to research CO₂ emissions in the
Holcim group, of about 30 cement companies in the group only seven were
monitoring their emissions. These seven companies were employing six differ-
ent, often vastly divergent, methodologies. The Japanese and companies from a
number of European countries reported their energy consumption excluding the
energy coming from waste. In the US, companies were also employing different
methodologies, leading to an extremely low energy consumption and correspond-
ingly low CO₂ emissions.

The CSI members were worried that if those numbers were accepted as tech-
nically achievable, regulatory targets would be based on values they perceived
as being too ambitious, posing a business risk. They agreed to the need for es-
ablishing an industry-wide, globally harmonised standard for a reporting and
verification system.7 Here, one can clearly see that voluntary sectoral bench-
marking emerged out of a risk management approach, as a response to the

5 Interview with Bruno Vanderborght, former Head of Climate Change at Holcim, August
2017.
6 Interview with Vanderborght.
7 Interview with Vanderborght.
spectrum of climate change regulation.

In trying to devise a uniform standard Holcim eventually joined forces with the World Resource Institute and the WBCSD in creating the Greenhouse Gas (GHG) Protocol. Together with corporate executives from *inter alia* BP, Dow and KPMG and PricewaterhouseCoopers, Bruno Vanderborght, working for Holcim, was among the core advisors in the creation of the GHG Protocol (World Resources Institute and World Business Council for Sustainable Development 2001). The GHG Protocol was published in 2001 and in 2002 they released a protocol version specifically designed for the cement sector. CSI members obliged themselves to apply the protocol. Globally, about 65% of the cement production gets monitored on the basis of the protocol (Jessica Green 2013b, 153).

It would become mandatory for all CSI members to use the monitoring, reporting and verification (MRV) mechanism and report group average emissions (not the facility level). In 2003 CSI launched the CO$_2$ Accounting and Reporting Standard for the Cement Industry and in 2006 it began developing the Getting the Numbers Right (GNR) database, producing country and cement type specific benchmarks on CO$_2$ emissions and energy consumption in the cement industry.

Gibbs et al. (2000, 180), writing for the Intergovernmental Panel on Climate Change’s *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*, deemed the issue of confidential business information in the reporting of national emissions from cement production as highly problematic and emphasised the importance of masking the emissions of individual cement plants, either by creating confidential tracking and reporting systems or by solely reporting aggregate numbers. Responding to such challenges, albeit not at the level of national inventories but in the transnational domain, the CSI selected PricewaterhouseCoopers (PwC), one of the *big four* accounting firms, to manage the GNR database of cement producers’ environmental information as an independent third party in order to guarantee the confidentiality of individual companies’ information and compliance with competition law (Stigson, Egenhofer, and Fujiwara 2008, 62).

The allowance allocation for the 1st (2005-2007) and 2nd (2008-2012) periods of the EU ETS was based on historic emissions before MRV was available, so companies were able to convince their national authorities to grant them allowances on the basis of non-verified emissions. As they had been ‘economical
with the truth’, many cement companies in the first period had a huge excess of allowances (Betz and Sato 2006, 354).\(^8\)

According to Vanderborght, Holcim ‘naively’ provided correct emissions data, which eventually put it at a competitive disadvantage. As Holcim wanted to avoid the continuation of this disadvantage during the second ETS trading period, it lobbied a lot for improving the MRV system. This was initially received with disdain by other companies in the cement industry, but finally more and more companies realised that not having such system was causing distortions of competition.\(^9\)

In the third trading period the reduction target of the Commission seemed too ambitious to the cement industry. According to Vanderborght, the cement industry was of the opinion that their reduction target was not technically feasible, at least not when based on clinker, and so industry agreed that it would be beneficial to manage that regulatory risk by being forthcoming with GHG data and thus, in 2007, they published the GNR database (World Business Council for Sustainable Development Cement Sustainability Initiative, n.d., 6).\(^10\) The coverage of European emissions was so extensive that the consortium of consultants working on a “Methodology for the free allocation of emission allowances in the EU ETS post 2012” for the cement sector based their proposed benchmark on CSI data (Fraunhofer Institute for Systems and Innovation Research, Ecofys, and Öko-Institut 2009, 11). Thus, the cement industry successfully managed to use GHG emissions performance disclosure to influence the regulatory process.\(^11\)

In 2009, when the methodology for the free allocation of emission allowances in the EU ETS post 2012 was being elaborated, the WBCSD released some lengthy cement-related reports and one can observe a spike in the prevalence of cement-related topics and keywords on the WBCSD website (The Cement Sustainability Initiative 2009; World Business Council for Sustainable Development and International Energy Agency 2009; Cement Sustainability Initiative 2009), whose historical documents were downloaded via a dedicated script from the Internet Archive (Arora et al. 2016). Figure 8.2 shows some results of the application of a 140 topic model to the corpus of documents on the WBCSD (on topic modelling see Blei and Lafferty 2007; Roberts, Stewart, and Tingley

\(^8\) Interview with Vanderborght.
\(^9\) Interview with Vanderborght.
\(^10\) Interview with Vanderborght.
\(^11\) Remember the suggestion by Stigson et al. (2008, 44) that sectoral benchmarking initiatives may be well suited for informing the distribution of free emissions permits?
8.5. Cement

Five of the topics are strongly associated with cement and concrete. Based on the terms strongly associated with the topics, the topics were labelled as Cement Sustainability Initiative, Cement and Concrete Mixes and LCA, Cement Industry Raw Material Extraction, Emissions and Waste as a Fuel, and Cement Industry and / as Stakeholders. The first figure shows the percentage of topic contributions to the corpus normalised by number of documents and the second figure normalised by document length. The second figure shows the peak of cement-related topic prevalence in 2007, when the GNR database was published, and the second in 2009, when the methodology for the free allocation of emission allowances in the EU ETS post 2012 was being elaborated.

In parallel, a dictionary method for quantitative text analysis (Welbers, Van Atteveldt, and Benoit 2017; Benoit 2018) permitted to obtain metrics on the prevalence of terms related to the LCA/EPD/PCF issue area. Figure 8.3 shows that the peak of the occurrence of LCA/EPD/PCF related keywords per 100k words on the WBCSD website coincides with that indicated by the topic model, when the topic contribution to the corpus is adjusted by document length. Altogether, one can observe how the spike in the prevalence of LCA and cement discourse on the WBCSD website coincides in time with the elaboration of ETS benchmarks for the cement industry.

Below one can see that some of the informational infrastructure erected by the CSI went on to be further utilised for the creation of cement EPDs.

Regional and national sectoral associations also gather environmental data. Here, there are stark differences between the USA, on the one hand, and the EU, Germany and the UK, on the other hand.

In 2012 the Association of German Cement Plants (VDZ) published an EPD for German cement. In the process of creating the EPD “almost all the German cement and grinding works .. provided information on the material and energy resources” for the year 2010 (Verein Deutscher Zementwerke 2012, 140). When VDZ collected data for their sectoral EPD, it was important to achieve a high

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12See the Appendix, Section A.8, for the most prominent words associated with the topics.
13See Appendix, Section A.10, for a list of keywords.
14The strong fluctuations in the number of documents in Figure 8.3, in particularly the extremely low document numbers in the years 2009-2015, are striking. In order to rule out that this is an artefact of my data retrieval and preparation procedure, one can compare it to Wayback Machine statistics on HTML and PDF files on the WBCSD website (see Table A.8 in the Appendix, Section A.9). The Wayback Machine statistics confirm the massive drop in the number of documents from 2008 to 2009 and the slight rise in 2016. However, these data fluctuations could still be an artefact of the Wayback Machine (Leetaru 2015).
Figure 8.2.: Occurrence of cement sustainability and LCA related topics in documents on the WBCSD website
Figure 8.3.: Occurrence of LCA/EPD/PCF related keywords in documents on the WBCSD website
turnout of the survey, with which they collected data from their member companies, in order to be able to claim representativeness of the EPD. In order to achieve a high turnout, members need to trust that their data would be handled in a confidential way. Achieving this trust was facilitated by the fact that the VDZ had already been surveying the environmental data of the German cement factories for a long time.\footnote{Interview with VDZ, September 2017.}

Already in 1995 the German cement industry took on the voluntary obligation to reduce its energy consumption. The VDZ has been collecting environmental performance information at least since September 2000 (VDZ 2013, 3). Only two months later the German Federal Government and major industry associations agreed to a climate deal with GHG emissions reduction targets and a monitoring mechanism (German Federal Government and German Business Representatives 2000). The German cement industry agreed with the government to reduce its specific energy-related CO$_2$ emissions between 1990 and 2012 by 28%. As part of the third-party monitoring of the CO$_2$ emissions targets the VDZ collected the corresponding data from its members on an annual basis (Verein Deutscher Zementwerke 2017; Rheinisch-Westfälisches Institut für Wirtschaftsforschung 2013). Consequently, the cement manufacturers were already accustomed to the VDZ’s data gathering exercises.\footnote{Interview with VDZ.} This shows an additional potential channel for data gathering activities, which could prepare the creation of sectoral EPDs.

The VDZ also provides a “country-specific material-related emission factor from plant-specific data” for the calculation of cement production process-related CO$_2$ emissions on which the National Inventory Report for the German Greenhouse Gas Inventory draws (Herold, Anderson, and Jörß 2016, 42; Umweltbundesamt 2013). This is another institutionalisation of the role of trade associations as informational intermediaries, which can then be useful for LCAs.

As the case of the German cement manufacturing association suggests, voluntary agreements between sectors and governments can have conducive effects for EPD creation. The VDZ has been collecting environmental company data for many years, not least to provide accountability for the voluntary agreements between the sector and the government. By drawing on these data gathering efforts, EPD creation was a fairly smooth process.

In 2014 the UK Mineral Products Association (MPA) issued an EPD for UK
Average Portland Cement, based on 2011 data from different sites in the UK, owned by CEMEX, Hanson, Lafarge Tarmac, and Hope Construction Materials (Mineral Products Association 2014).

For the case of the UK, Jane Anderson, who used to work on building product LCAs with the UK Building Research Establishment (BRE) and later with Thinkstep, states that in working with trade associations, sometimes one gets sent the data by each individual company, because of the way they deal with confidentiality. This suggests that prior corporatist arrangements, where a trade association collates environmental data for reporting towards the government, can help to reduce transaction costs for later EPD production, as the data is already in a standardised format before LCA consultants receive it.

Data collection should have been facilitated by the fact that MPA “[c]ement members have participated in a [Climate Change Agreement (CCA)] since the scheme started in 2001” (UK Mineral Products Association 2018). In the UK the Climate Change Levy (CCL) and CCAs were introduced in the year 2000. CCAs between the government and energy-intensive sectors have included the requirement for “[p]articipants … to report their energy/carbon and production data to the sector association” (UK Department of Energy and Climate Change 2008, 4). This should strengthen the mediating role of these sector organisations.

In 2015 European cement trade association Cembureau released an EPD for blast furnace cement (CEM III) produced in Europe. Next to statistical information from Cembureau itself and national and company level EPDs it also draws on “publicly available information from [the GNR database] … particularly related to the fuel mix, electricity consumption and CO₂ emissions”. Cembureau (2015b, 5) points out that the “independent third party service provider PwC runs the database [, which] includes providing appropriate data quality checking procedures”.

According to Vanderborght, risk management in the face of potential carbon constraining policies was an important motivation leading to the establishment of the GNR database. Now Cembureau drew on the data for producing EPDs. In order to gauge the significance of this reliance on GNR data, one would need to know the difference the availability of GNR made to the release of this EPD. Would Cembureau’s own data have been sufficient for the release of a credible EPD? Has GNR significantly lowered barriers for the production of such an EPD? The thorough exploration of a counterfactual scenario is beyond

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17Interview in 2017.
the scope of this work. What could be well established is that the cement industry’s management of regulatory risks has indirectly aided the production of EPDs. While it may not have been a necessary precondition, it is likely that it has facilitated and thus speeded up EPD production.

In 2012 the CSI (2012, 25) was “developing a common methodology to quantify the environmental impacts of concrete, using life-cycle assessment (LCA) methodology”, in order to aid the publication of EPDs. In 2014 the CSI released the international version of their EPD Tool. The US Version, sponsored by the US Portland Cement Association (PCA), was modified to follow Product Category Rules for US cement and ready mixed concrete and contained US-specific energy profiles. The tool facilitates the generation of sector-specific EPDs for cement, clinker and concrete (ASTM International, n.d.).

The PCA, which claims to “represent 92 percent of US cement production capacity” (Portland Cement Association n.d.), used the CSI EPD Tool to compute LCAs for three industry average cement EPDs, which were released in 2016. One of the PCA EPDs was then incorporated into the data basis of the National Ready Mixed Concrete Association’s EPD for ready-mixed concrete, as cement is a component of concrete (National Ready Mixed Concrete Association 2016).

Prior to the EPD creation the PCA lacked accurate national averages for some of the underlying data. PCA members have traditionally reported energy use to the Environmental Protection Agency (EPA) and Department of Energy (DoE) as part of ongoing reporting. Prior to the EPD data gathering efforts, the PCA had to rely on publicly available data through the EPA and DoE, and data extrapolated from emission factors which were published with the International Energy Agency (IEA).

The EPA requires that major manufacturing companies submit reports on their emissions. That has been an ongoing program for decades. CO₂ only began relatively late to play a role there, long after e.g. SO₂ and NO₂. Due to EPA requirements, data monitoring and reporting processes were already in place and so PCA members already had initiatives internally that were applicable for the same type of thing, and in many cases that information is simply repurposed. In the case of the EPD, there were additional data points that were required to be collected.

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18 Interview with PCA representative in August 2017.
19 Interview with PCA.
20 Interview with PCA.
21 Interview with PCA.
8.5. Cement

Many industrial facilities already had installed continuous emissions monitoring systems (CEMS) in order to comply with EPA’s reporting requirements on criteria pollutants, like sulphur dioxide, and many of these reporting systems can also track CO$_2$ emissions (Richardson 2012, 6). This means that many facilities may have had the ability to track CO$_2$ emissions even without specific EPA CO$_2$ reporting requirements. Yet, being able to track these emissions does not necessarily translate into the kind of orderly and verified reporting on which the PCA could eventually base their EPD creation efforts.\footnote{Interview with PCA.}

For the EPD creation PCA was able to get plant specific information from about 75% of the cement plants in the USA. PCA members provided production data to the market intelligence department within PCA. That information got sent to PCA confidentially, where it was analysed for quality. On occasion, a plant would report something which they understood as a different name or boundary condition and their results would deviate by an order of magnitude of two or three from the industry average. PCA would then have to call them to understand what they were reporting, to improve the data quality.\footnote{Interview with PCA.}

The WBCSD CSI played an important role in the run-up to the issuances of the PCA EPD as it provided the methodology and a software tool for the creation of cement EPDs, which \textit{de facto} already provided standardised parameters for the LCA. As shown above, the expectation of regulation and risk management were a major motivating element for Holcim and the CSI to become active in this domain. While it would probably have been possible for the PCA to do without this prior work, it is difficult to assess how intensive and difficult it would have been to agree to such common standards.

In contrast to its peers in Germany and the UK, the PCA had much less privileged access to its members’ energy and climate data. Prior to their EPD data gathering efforts, the PCA had to rely on data publicly available through the EPA and DoE. The PCA also had to extrapolate data from emission factors published by the International Energy Agency (IEA). As the PCA was lacking accurate national averages for some of the data needed for their EPD, they still had to collect, compile and validate additional information. Those were time and resource intensive activities.\footnote{Interview with PCA.}
8.6. Results and discussion

The corporatist aspects of benchmarking under the EU ETS and the elaboration of BREFs under the IPPC are probably conducive to the creation of sectoral EPDs, as both provide incentives for the intra-sectoral sharing of information. Once a trade association has taken on the task of collecting data for the purpose of benchmarking, it can use the same organisational structure to also gather data for the production of sectoral EPDs.

Figure 8.4 compares the schedule of the elaboration of the first BREF series from 1997 to 2008, from the kick-off meetings to the acceptance of the BREFs (BREF schedule based on Schoenberger 2009, 1529), with the publication of European LCI information from related industries. One can observe significant overlaps between the BREF elaboration schedule and the creation of LCIs. In the case of the cement sector, the BREF elaboration schedule did not directly overlap with the creation of sectoral LCIs but with the founding of the CSI, which would eventually create data used in EPDs. The hypothesis that there was a temporal overlap between the IPPC process and LCA creation, with the IPPC process or its anticipation preceding LCA creation can be confirmed.

It would be fraught with difficulties to firmly establish on the basis of these findings that there is a causal mechanisms accounting for the temporal proximity of LCA releases and the IPPC process. The mere temporal correlation between the BREF elaboration processes and the release of LCIs by industry does not prove Proposition 4a that the IPPC process facilitated LCA creation by providing incentives for industrial sectors to enter or deepen a coordinated exchange of information on the environmental impacts of production. Neither would the absence of such a correlation disprove the proposition. However, had the release of European LCA information regularly occurred significantly before the BREF elaboration phases, the relevance of the proposed mechanism would be diminished. The presence of a temporal correlation and the regular temporal succession, with BREF elaborations processes tending to coincide with or precede LCA releases, does constitute tentative evidence in support of the proposition. In order to test the causal mechanism more clearly, a more detailed reconstruction of events would be necessary, going beyond the scope of the present work.

25 Large volume organic and inorganic chemicals (as solids) and organic fine chemicals and specialty chemicals were excluded from the list, as these are all rather broad categories. So was everything that was not considered as belonging to the rubric of basic materials.
8.6. Results and discussion

Figure 8.4: Schedule of the elaboration of the first BREF series from 1997 to 2008 and European LCI publications.

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996</td>
<td>Initiation of Cement Sustainability Initiative</td>
</tr>
<tr>
<td>1997</td>
<td>International Iron and Steel Institute publishes its first LCI in 1995/6</td>
</tr>
<tr>
<td>1998</td>
<td>Conference on Steel Environment Programme results and Iron and steel BREF</td>
</tr>
<tr>
<td>1999</td>
<td>Publication of European Database for Corrugated Board Life Cycle Studies</td>
</tr>
<tr>
<td>2000</td>
<td>Pulp and paper BREF</td>
</tr>
<tr>
<td>2001</td>
<td>Plastics Europe publishes Eco-Profiles as stand-alone report</td>
</tr>
<tr>
<td>2002</td>
<td>Polymers BREF</td>
</tr>
<tr>
<td>2003</td>
<td>No information available on European life cycle inventories (LCIs) for ceramics</td>
</tr>
<tr>
<td>2004</td>
<td>Ceramics BREF</td>
</tr>
<tr>
<td>2005</td>
<td>European average values for fertilisers available for 2006</td>
</tr>
<tr>
<td>2006</td>
<td>Large volumes inorganic chemicals (Ammonia, Acid, and Fertilisers) BREF</td>
</tr>
<tr>
<td>2007</td>
<td>No indication for a general European refineries LCI / Eurobitume published LCI in 1999</td>
</tr>
<tr>
<td>2008</td>
<td>Refineries BREF</td>
</tr>
<tr>
<td>2009</td>
<td>First LCA of European container glass in 2009</td>
</tr>
<tr>
<td>2010</td>
<td>Glass manufacturing BREF</td>
</tr>
<tr>
<td>2011</td>
<td>International Aluminum Institute begins data gathering for LCI</td>
</tr>
<tr>
<td>2012</td>
<td>Non-ferrous metals BREF</td>
</tr>
<tr>
<td>2013</td>
<td>LCI by European Chlor-Alkali industry only published in 2013</td>
</tr>
<tr>
<td>2014</td>
<td>Chlor-alkali manufacturing industry BREF</td>
</tr>
<tr>
<td>2015</td>
<td>Initiation of Cement Sustainability Initiative</td>
</tr>
<tr>
<td>2016</td>
<td>Cement and lime BREF</td>
</tr>
</tbody>
</table>

The years are "rounded".
8. ‘We’ve got that data already’. Industry sector environmental accountability and EPDs

Yet, at least with the case of the cement sector, one can see that risk management in the face of potential regulation has motivated industry to benchmark their environmental impacts, and to come up with a methodology for doing so. Information provision is an important part of lobbying (Broscheid and Coen 2007). In the case of the CSI one could observe that the desire to manage the risks of regulation was an important motivation for pursuing a sectoral approach. It was part of the risks management to come up with a coherent methodology, in order to avoid emissions reduction targets that cement companies would have found overly ambitious. Once set-up, the initiative eventually helped to provide the tool for the creation of the first US sectoral cement EPD, and Cembureau’s European cement EPD also drew on the CSI’s GNR dataset. The spectre of regulation and the promise of free allocation of emissions permits motivated industry to institutionalise the sharing of information among themselves in order to provide benchmarks. This eventually helped to provide data for LCA. Here, the hypothesis that there is a causal sequence leading from coordinated exchanges of information within the context of a sectoral approach to the generation of LCA data can be confirmed. In addition, in Germany and the UK a lot of the informational infrastructure for the eventual data gathering needed for EPD production was already in place, so that national level cement manufacturing data could be repurposed for EPD production. Altogether, the transaction costs for the German and UK cement manufacturers’ sectoral EDP should have been much lower than for the US cement manufacturers’. Thus, in at least one case there is good evidence that a political environment that sets incentives for an intra-sectoral exchange on the environmental impacts of production was conducive to the creation of sectoral life cycle data sets. And in other cases there is good reason to assume that similar mechanisms may have been at play.

There is another potential causal mechanism leading from sectoral initiatives to the creation of sectoral EPDs, which I did not test here, but which is worthy of contemplation: it may well be that sectorally organised exchanges on the environmental impacts of production have not only lowered the transaction costs for the eventual creation of LCAs and EPDs but have also strengthened the role of environmental experts within companies and trade associations. These expert may have both material and ideological motivations for promoting the release of information on the environmental impacts embodied in products. That means they would form a constituency for LCAs.
8.7. Recommendations

A further, and more conclusive, testing of the proposition that the IPPC process facilitated LCA creation by providing incentives for industrial sectors to enter or deepen a coordinated exchange of information on the environmental impacts of production would perhaps most effectively be accomplished by detailed qualitative examinations of the historical interactions, at the level of micro-processes, among firms and trade associations in specific sectors.

As there is already good evidence that policies which provide incentives for sectoral data sharing have facilitated the diffusion of EPDs, future evaluations of the qualities of different policies would do well to include considerations of such unintended side-effects.

Policy-makers who wish to promote the diffusion of EPDs may be able to complement informational pull, for example via public procurement, with the sort of informational push that can be stimulated by adopting policies which provide incentives for intra-sectoral information sharing.

While intra-sectoral information sharing may be problematic where it facilitates anti-competitive collusion in the form of cartelisation, once firm-specific EPDs are phased in, new policies can help to stir competition over the lowest embodied environmental impacts.

8.8. Conclusion

Environmental policies that rely on deliberation and coordination between government and industry peak organisations provide incentives for companies to engage in the sectoral sharing of environmental data. The sharing of such data, and the establishment of institutions for this purpose, reduces the transaction costs for the creation of sectoral EPDs and is conducive to the diffusion of labels that inform about the environmental impacts embodied in products. Once sufficient information about the environmental impacts embodied in products becomes available, new consumption-based environmental policies can be constructed on such an extended informational basis.

Against those who argue that standards are less efficient than market-based approaches, and therefore less desirable, this chapter makes the case that there are good reasons to assume that standard-setting processes have helped to stimulate intra-sectoral information exchange processes conducive to the creation
of sectoral LCAs. In the form of EPDs, such sectoral data can help to inform consumption-based approaches in climate policy. One of these approaches, border carbon adjustments, has the potential to enable a radical raising of carbon price levels and to make good on carbon pricing’s promise of technology and material neutrality. The setting of standards at time \( t1 \) may thus help to improve the viability of pricing schemes at time \( t2 \).

Against those who argue that carbon policy lacks the potential to mobilise business in its support, this chapter has shown that the anticipation of the risks arising from carbon policy has been conducive to the creation of sectoral EPDs. The availability of such EPDs makes new policies feasible, which enables the formation of new business coalitions in favour of embodied emissions policies. This may be regarded as an indirect mobilisation effect. If the availability of EPDs goes on to enable future border carbon adjustments, the cost-benefit distribution of carbon pricing among firms should become significantly transformed, which may offer opportunities for changes in the pattern of business mobilisation in favour or against carbon pricing.

While this chapter has addressed the effects of policy on data availability at the sectoral level, the next chapter looks at the firm level.
9. Rescoping from firm to product level

Companies around the world are more and more subject to environmental reporting requirements. Kareiva et al. (2015, 7378) suggest that “the same environmental indicators that inform corporate reports could ideally inform the labeling of products and in turn influence consumers” and that there may be spillover effects from corporate environmental disclosures to product labelling. Whereas they do not provide more specific mechanisms by which such a spillover may occur, I remedy this here by advancing propositions on underlying mechanisms. Section 9.1 spells out theoretical background and propositions, and Section 9.2 the methodology. Section 9.3 suggests that there are significant, or non-trivial, costs involved in the production of EPDs and PCFs. Section 9.4 looks at how greenhouse gas (GHG) reporting requirements induce the build-up of capacities for environmental accounting within firms. I examine the build-up of data and capacities in response to production-based environmental monitoring requirements by analysing statements made by hundreds of—the often multinational—companies with headquarters in Africa, the Americas, Asia, Australia, and Europe. Section 9.5 then examines how the build-up of capacities for production-based accounting facilitates the production of EPDs and PCFs. Here I triangulate interview results with grey and secondary literature. After a discussion of my findings, I conclude that, indeed, there is a range of spillover effects from production-based environmental monitoring and reporting to product-based environmental disclosure of life cycle impacts.

9.1. Theory and propositions

Kareiva et al. (2015, 7378) do not clarify why they focus solely on annual corporate environmental disclosures rather than on environmental reporting requirements more generally, including those at the site-level. In the following I deal with both types.

1For simplicity’s sake, here I subsume the ‘site level’ under the ‘firm level’ to contrast it with the ‘sectoral level’.
9. Rescoping from firm to product level

Following Kareiva et al. (2015, 7378), I base my argument for explaining the rescoping from place-based to place-less environmental disclosure on the causal mechanism of spillover effects.

One needs to distinguish between latent spillovers from an activity \( a \), which could potentially exert effects on activity \( b \), and manifest spillover effects, which actually exert effects on activity \( b \).\(^2\) Where one is solely interested in explaining the past, attention will naturally gravitate to manifest spillover effects. Those who wish to engage in forward theorising, “to identify possible policy interventions and reason forward to how the problem and interventions might unfold over time” (Levin et al. 2012; in Bernstein and Hoffmann 2018, 206), may also wish to consider latent spillovers.

In order to assess to what extent there are spillovers from different production-based monitoring and reporting requirements to life cycle product data, we need to examine how one kind of activity provides functional benefits for the other kind of activity. In the following I advance a number of more specific spillover effects that support my overarching proposition that

**Proposition 5 (P5)** Production-based environmental monitoring and reporting has spillover effects and thus drives down various costs for eventual product level disclosure of life cycle impacts

Figure 9.1 depicts this proposition visually.

What causal mechanisms would make production-based monitoring and disclosure a driver for product level disclosure? As the primary underlying causal mechanism, I propose spillover effects by which investments into a better monitoring and reporting of production-based environmentally relevant activities also lower costs for places-less disclosure of information on environmental flows. This should then be conducive to the availability of information on the environmental impacts embodied in products. This proposition is composed of several sub-propositions on the underlying micro-mechanisms:

**Proposition 5a (P5a)** External environmental monitoring and reporting requirements lead companies to acquire better data on environmentally relevant aspects of production activity

\(^2\)Spillovers do not need to become manifest in the form of effects. They could lie unnoticed, only with the potential to affect a cost-benefit calculation, without necessarily serving for an actual calculation. Even if spillovers affected such a calculation, the calculation might not necessarily precipitate further action; the effects may thus not manifest in the form of external action. Spillovers also may not necessarily enter any cost-benefit calculations, yet they could still have effects, even if unnoticed.
9.1. Theory and propositions

Proposition 5b (P5b) Better data on environmentally relevant aspects of production activity can then be transformed into life cycle environmental data at the product level.

Figure 9.2 illustrates both propositions.

Proposition 5c (P5c) External environmental monitoring and reporting requirements lead companies to acquire more expertise on production-based monitoring and disclosure.

Proposition 5d (P5d) More expertise on production-based monitoring and disclosure then becomes available for the creation of life cycle environmental data at the product level.

Figure 9.3 illustrates these two propositions.

Proposition 5e (P5e) External environmental monitoring and reporting requirements lead companies to acquire more organisational and technological resources for production-based environmental monitoring and disclosure.
9. Rescoping from firm to product level

- External environmental monitoring and reporting requirements
- Improved availability of data on environmentally relevant aspects of production activity in companies
- Life cycle environmental data at the product level

Figure 9.2.: Propositions 5a and 5b
9.1. Theory and propositions

External environmental monitoring and reporting requirements

P5c: increase

Company expertise on production-based monitoring and disclosure

P5d: can be utilised for

Creation of life cycle environmental data at the product level

Figure 9.3.: Propositions 5c and 5d
9. Rescoping from firm to product level

Proposition 5f (P5f) *More organisational and technological resources for production-based environmental monitoring and disclosure then become available for the creation of life cycle environmental data at the product level*

Figure 9.4 illustrates these two propositions.

Figure 9.5 shows the six propositions on the causal mechanism, leading from policies and initiatives targeted at increasing the information on environmentally relevant aspects of production activity to the availability of information on the environmental impacts embodied in products. We can see that propositions 5a, 5c, and 5e concern the relation between the institutional environment and the level of the firm. Propositions 5b, 5d, and 5f concern the relation between the level of the firm and the level of the product.

Would such a reduction of costs be relevant? To find that out, I introduce an auxiliary proposition:
9.1. Theory and propositions

Figure 9.5.: Propositions on causal mechanisms leading from policies and initiatives targeted at increasing the information on environmentally relevant aspects of production activity to the availability of information on the environmental impacts embodied in products
9. Rescoping from firm to product level

Proposition 6 (P6) The collection and validation of data for the disclosure of the life cycle impacts of a product is somewhat expensive

9.2. Methodology

The methodology is split between an analysis of the impacts of the institutional environment on the firm level, on the basis of an analysis of CDP survey results, and an analysis of how such impacts may affect the propensity of firms to produce EPDs and PCFs, based on interviews, literature and social network data. To empirically validate the propositions advanced in the prior section, I deduced a number of hypotheses on what one should empirically observe if the propositions are either correct or false (Hall 2013, 21).

To empirically validate my propositions about the changes induced within companies by environmental monitoring and reporting requirements I examined the CDP 2015 investor dataset, which provides company statements on responses to the risks and opportunities associated with different climate policies. In 2015 1896 organisations participated in the flagship CDP survey, which comprises publicly disclosed data collected on behalf of investors. I only focused on those organisations that indicated regulatory risks and/or opportunities from emission reporting obligations. 650 organisations did so. Of these, 300 organisations indicated that emission reporting obligations would constitute a regulatory opportunity and 512 that emission reporting obligations would pose a regulatory risk.

I was interested in whether companies can simply enact such disclosure, or reporting, or if they need to undergo significant internal change processes in order to comply with external requirements. If they must allocate internal resources and change processes, then these changes may also result in spillovers that can benefit product level LCA-style type of disclosures.

Using the text analysis software MAXQDA I coded statements, when applicable, into the following categories: those who stated that the availability of environmental data improved as a result of climate-related reporting obligations, those that mentioned systems or technologies as a response to reporting obligations, and those that needed to allocate human resources for that purpose.

The coding I conducted was similar to content analysis by virtue of being a method by which information is codified into categories in order to obtain quantitative metrics. Krippendorf (2004, 18) defines content analysis as “a
9.2. Methodology

research technique for making replicable and valid inferences from texts ... to the contexts of their use.

However, for Krippendorf (2004, 217ff.), for content analysis to be rigorous one needs to implement methods for making sure that the results can be reliably reproduced. An important aspect in order to test for such replicability is the measure of intercoder reliability. Intercoder reliability is a measure that has been developed in order to evaluate the whether coders perceive that text segments belong to the same categories. In order to obtain such a measure, one needs to let at least two people code a significant number of the same texts independently of each other. This obviously requires more resources than only one person coding texts.

I have not had a second person apply the set of codes independently. However, my code system is relatively simple. As an external quality control measure I also supply all of the coded segments as part of the Appendix (Section A.2). Furthermore, for the purposes of my argument it is not important to specify the exact number of documents that indicate the presence of specific causal relations or factors. I am only interested in the fact that there is a non-trivial number of companies that indicate that certain causal relations or factors were present. There may be more instances of the selected change processes in the dataset than I managed to identify. However, that would only make my argument stronger. I also do not use the resultant dataset as a basis for combining it with another one to draw causal inference. Therefore, there is less need for reliability.

I present percentages across sectors and regions, as the CDP data were already largely pre-structured in this way. These results should only be indicative of the presence of the stated phenomena, not the absence. The survey responses are not standardised enough to infer that the absence of such indications would imply the intention of a company to signal the absence of the phenomena (not) referred to.

Any analysis of survey results, and in particular where respondents are not anonymous, needs to deal with the problem of social desirability, which refers to the tendency of respondents to acknowledge socially desirable traits and behaviours and to deny those that are considered socially undesirable (Phillips and Clancy 1972, 923; Krumpal 2013, 2028). I expect that companies have an interest in presenting themselves in a very positive light, to ‘talk up’ their

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3However, I did aggregate EU member countries up to that level, as they are subject to common directives.
9. Rescoping from firm to product level

prospects towards investors, and to appear more legitimate towards stakeholders. Where companies simply explain that they are better equipped to deal with regulations than their competitors, this can be deemed socially desirable but not necessarily trustworthy. Where they, however, explain details of their operational procedures, and thereby acknowledge a less than optimal current or prior state, I deem such statements as more trustworthy. Overall, the changes within organisations, on which I focus, seem rather technical, and I just report them as if we could expect them to be true. Yet, there are certainly plenty of incentives for companies to portray themselves in the best light possible.

There are many other studies analysing the Investor CDP dataset. However, these pursue different research questions: many studies are primarily interested in the voluntary ‘disclosure’ aspects related to the CDP survey, and its determinants (see e.g. Reid and Toffel 2009; Dawkins and Fraas 2011; Luo, Lan, and Tang 2012; Stanny 2013). Others look at the effects carbon emissions and disclosure may have on firm value (see e.g. Haigh and Shapiro 2011; Matsumura, Prakash, and Vera-Muñoz 2013; Plumlee et al. 2015). Gasbarro et al.’s (2017) quantitative study on the ‘drivers of multinational enterprises’ climate change strategies’ focuses on the relation between the standardised response items that link climate change-related risks and opportunities with actual or anticipated impacts. Luo and Tang’s (2016) quantitative study on the ‘determinants of the quality of corporate carbon management systems’ constructs the quality of carbon management systems based on a composite index of several standardised values that the CDP survey offers.

While purely quantitative studies help to elucidate the relation between the standardised options provided by the CDP dataset, an analysis of the non-standardised free form responses allows us to penetrate deeper into the specificities of change processes within companies.

The CDP dataset is very rich and many papers have applied content analysis to it, with various research questions in mind. Luo and Tang (2014) use content analysis to measure the extent of carbon disclosure, Matisoff et al. (2013) to measure extent and variation in carbon reporting. Yunus et al. (2016) conducted a content analysis of responses to the CDP survey and other corporate statements in order to find out whether a company had adopted a carbon management strategy (CMS). However, they are not interested in the process of adoption and thus reduce the results to a dichotomous variable (Yunus, Elijido-Ten, and Abhayawansa 2016, 165).
9.2. Methodology

Freedman and Jaggi (2011, 48) conducted a content analysis of CDP survey results in order to evaluate GHG disclosures by firms. They developed an index to measure the extensiveness of disclosure (ibid., p. 78). Sales de Aguiara and Bebbington (2014, 231) coded disclosure statements on the basis of an index in order to measure volume of disclosure, completeness of disclosure, and the spread of disclosure.

Freedman and Jaggi (2011, 89) had two persons independently code the dataset and then they compared the results and worked towards a consensus. Sales de Aguiara and Bebbington (2014, 233) also employed two coders, who worked towards a consensus, with additional checks on replicability of the results by a third coder.

The indices developed by the above mentioned authors are relatively complex, seeking to generate metrics with various intervals along different continuums. In contrast, I only apply binary categories that indicate the presence of a phenomenon or its absence. With such greater simplicity, there is less need for generating measures of intercoder reliability.

My analysis contributes to the literature by providing a medium to large set of quotes which indicate that in many companies external reporting requirements indeed lead to significant changes in terms of resource allocation, systems implementation and data availability. While these findings do not stretch the imagination very far – indeed, they may be considered trivial – they provide important systematic empirical support for theories of spillover effects from site or firm level monitoring and reporting to product level reporting of life cycle impacts.

To find out more about the rescoping of information from firm or facility level to product level I conducted a number of in-depth semi-structured expert interviews. Table 9.1 shows the interviews and correspondences that I draw on here. While the list of interviewees is rather short, all of them are deeply involved in the field of LCAs and its nexus to EPDs or PCFs. Most of the interviewees are seasoned experts in the field who have an overview of how historic developments have unfolded over the last decades. Where possible, I triangulated the results from the interviews with grey and secondary literature.
Table 9.1.: Interviews and correspondences drawn upon

<table>
<thead>
<tr>
<th>Interviewees</th>
<th>Organisation</th>
<th>Position</th>
<th>Year</th>
<th>Region</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jane Anderson</td>
<td>Thinkstep, independent EPD verification company, formerly BRE</td>
<td>Consultant with Thinkstep</td>
<td>2017</td>
<td>UK</td>
</tr>
<tr>
<td>Anonymous</td>
<td>IBU</td>
<td>Senior representative</td>
<td>2017</td>
<td>Germany</td>
</tr>
<tr>
<td>Morgan Jones</td>
<td>Carbon Trust</td>
<td>Associate Director</td>
<td>2017</td>
<td>UK</td>
</tr>
<tr>
<td>Danny Püschel</td>
<td>Gebäude-Allianz and NABU</td>
<td>Coordinates the department responsible for EPDs in a company that produces LCAs for buildings and building materials</td>
<td>2017</td>
<td>Germany</td>
</tr>
<tr>
<td>Joep Meijer</td>
<td>Right Environment</td>
<td>President</td>
<td>2017</td>
<td>USA / Europe</td>
</tr>
<tr>
<td>Mark Goedkoop</td>
<td>PRé</td>
<td>Founder</td>
<td>2017</td>
<td>Netherlands / Global</td>
</tr>
<tr>
<td>Anonymous</td>
<td>DGNB</td>
<td>Staff member</td>
<td>2016</td>
<td>Germany</td>
</tr>
<tr>
<td>Anonymous</td>
<td>PCA</td>
<td>Staff member</td>
<td>2017</td>
<td>USA</td>
</tr>
<tr>
<td>Anonymous</td>
<td>Major sustainability consultancy</td>
<td>Senior representative</td>
<td>2017</td>
<td>Western Europe and Americas</td>
</tr>
</tbody>
</table>

9.3. Is the production of EPDs or PCFs costly?

Let us now look at Proposition 6, that *the collection and validation of data for the disclosure of the life cycle impacts of a product is somewhat expensive*. This
9.3. Is the production of EPDs or PCFs costly?

Proposition is obviously a rather imprecise one. However, if the proposition is correct, one would expect the hypothesis to be confirmed, that the overwhelming majority of sources state that the creation of EPDs involves significant financial costs or work. If the proposition is false, one would expect the hypothesis to be rejected.

Table 9.2 shows a number of statements indicating that significant costs, or labour time, are involved, particularly in LCAs that comprise site-specific data. More detailed results can be found in the Appendix Section A.3.

<table>
<thead>
<tr>
<th>Source</th>
<th>Costs</th>
<th>Work time</th>
</tr>
</thead>
<tbody>
<tr>
<td>European Environment Agency (1997, 59)</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>Anderson et al (2006)</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>ift Rosenheim (n.d.) (Construction product testing institute)</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>Interview with Danny Püschel</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>Interview with Joep Meijer</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>Interview with Portland Cement Association (PCA)</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>Interview with DGNB representative</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>The Economist (2011)</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>NRMCA (n.d.)</td>
<td>***</td>
<td>***</td>
</tr>
</tbody>
</table>

Based on the statements represented in Table 9.2 I conclude that EPD creation is somewhat costly – whatever that means for specific companies, who obviously vary considerably in terms of size, sectoral affiliation, etc.

While the collection of these sources is far from a systematic review of the literature or a large number of systematic interviews, the results are unambiguous. If they were more ambiguous, a larger sample or a more in-depth analysis would certainly be warranted.
9. Rescoping from firm to product level

9.4. From institutional environment to site and firm level

9.4.1. Drivers of production-based environmental monitoring and reporting

I conceptualise different monitoring and reporting requirements in companies as layers that can partly complement each other or that may be partly redundant, i.e. different requirements may repeat. Synergies can be found where requirements of one scheme are already fulfilled in compliance with another scheme and, thus, there is no additional work load. Synergies may also be achieved where the build-up of capabilities for monitoring and reporting in compliance with specific requirements reduces the costs for complying with other requirements.\footnote{For example, Potoski and Prakash (2005) suggest that more stringent regulations make it more likely that firms will adopt voluntary environmental management systems in the form of ISO 14001. Here a stricter regulatory environment may reduce the relative costs of adopting an additional scheme.}

Figure 9.6 shows a number of layers of production-based environmental monitoring and reporting within companies in stylised form. I will discuss most of these different layers, one by one, further below. Energy efficiency obligations will be discussed in Chapter 10.

9.4.1.1. Facility and installation-level reporting

Facility and installation level environmental reporting requirements are manifold. In many – if not most – countries polluting commercial activity requires companies to obtain environmental permits. This is, for example required by the US Clean Air Act (CAA) and the EU Integrated Pollution Prevention and Control (IPPC), as well as the succeeding Industrial Emissions Directive (IED) (Council of the European Union 1996, 30; U.S. Environmental Protection Agency 2007, 19; European Commission 2018).

Next to information provision as part of the permit process, there are also dedicated public reporting requirements for polluting installations. In the EU the reporting of emissions at facility level has been mandatory since at least the year 2002, with the European Pollutant Emission Register (EPER) and its successor, the European Pollutant Release and Transfer Register (E-PRTR) (European Commission 2000; European Commission 2017c; Krämer 2016, 178). GHG emissions reporting at facility level was already included in the reporting requirements for the EPER. However, this does not mean that the system was
Figure 9.6: Layers of production-based environmental monitoring and reporting within companies
9. Rescoping from firm to product level

sufficiently solid to prove reliant as a base for such demanding activities as the EU ETS.

In the USA the closest equivalent to the E-PRTR and its precursor would be the Toxic Release Inventory (TRI) (Hamilton 2005; Kraft, Stephan, and Abel 2011; Environmental Protection Authority (EPA) 2014). The TRI was established in 1986 in the aftermath of the 1984 catastrophic chemical accident in Bhopal, India (Kraft, Stephan, and Abel 2011). In 2009 the US EPA introduced a requirement for large emitters to report their greenhouse gas emissions at facility level (Knox-Hayes and Levy 2011, 2; United States Environmental Protection Agency, n.d.). While emissions from electric power generation from fossil fuels had already been tracked before, for most emitters the new program meant the first mandatory emissions tracking at the Federal level (Richardson 2012, 3f.). Many facilities already had installed continuous emissions monitoring systems (CEMS) in order to comply with EPA’s reporting requirements on other pollutants like sulfur dioxide, and many of these reporting systems can also track CO\textsubscript{2} emissions (Richardson 2012, 6).

Whereas in environmental permitting it is mostly important to remain below certain pollution thresholds, actual mandatory carbon pricing schemes like the EU ETS and the Californian cap-and-trade system require precise and verified estimates of emissions.

9.4.1.2. Environmental management

Since the 1990s many companies have formally adopted standardised voluntary environmental management systems (EMS). Companies seek environmental certifications under specific norms, in particular the ISO 14000 series on environmental management systems, and ISO 9001 for a quality management system, which requires monitoring and reporting of data. With the adoption of EMS companies had to, at least nominally, subscribe to a systematic approach to the collection of environmental data and the optimisation of their environmental efficiency.

In 1993 the Council of the European Union laid the base for a voluntary system of eco-auditing of industrial installations. In the 2000s the system, named the Eco-Management and Audit Scheme (EMAS), was eventually revised and opened to any form of organisation. In 2015 about 4,500 organisations with more than 8,100 sites were registered as EMAS participants (Krämer 2016, 183f.).

ISO 14001 was launched in 1996 (Campos et al. 2015, 287). In 2016 346,189
companies were certified according to ISO 14001 (International Organization for Standardization 2017).

In their discussion of EMS requirements in the context of ISO 14001 Prakash and Potoski (2006, 91) refer to a checklist of EMS components. Amongst these core checkboxes are questions whether the company has

- assessed the environmental impact of its operations and products in terms of their likelihood and severity,
- established specific and measurable environmental targets, and
- identified specific personnel responsible for achieving environmental targets.

This implies that somebody needs to be responsible for measuring at least some environmentally relevant energy and material flows. In the absence of other monitoring requirements, this may be another source of production-based environmental information, potentially usable as a basis for product-based disclosure.

While numerous studies have pointed out the environmental benefits of the adoption of the ISO 14001 standard, there have also been notes of caution. One reason for doubting that the adoption of the ISO 14001 standard necessarily leads to environmental improvements is the possibility of businesses solely adopting the standard in a symbolic manner, without really leveraging the EMS in order to improve environmental performance (Ferrón Vilchez 2017).

9.4.1.3. Corporate reporting

In corporate reporting one can see both the adoption of more general environmental and more GHG specific reporting, both in voluntary as well as in mandatory form. Let us first focus on general environmental reporting and then, further below, on specific GHG reporting.

The Global Reporting Initiative (GRI) has contributed to making environmental disclosure a more prominent issue in the corporate world (Knox-Hayes and Levy 2011). GRI claims that its Sustainability Reporting Guidelines are “the most widely used sustainability reporting framework in the world” (GRI 2013).

Signatories to the UN Principles for Responsible Investment, who commit themselves to incorporating environmental data into investment analysis and
decisions, collectively managed about 15% of global investable assets in 2013 (Kareiva et al. 2015, 7376). Such demands for sustainability data does not remain unmatched by supply: According to sustainability consultancy ERM (n.d.), the percentage of companies that are part of the Standard & Poor’s 500, a stock market index, who publish a sustainability report has grown from 20% in 2011 to 81% in 2016. By now, most major corporations have sustainability officers (Kareiva et al. 2015, 7376).

The EU Accounts Modernisation Directive (AMD) of 2003 (European Parliament and Council 2003) required larger businesses to complement their financial reporting with information on environmental matters, where appropriate.

Under Directive 2014/95/EU large public-interest companies with more than 500 employees are required to include non-financial statements, including on environmental protection, in their annual reports from 2018 onwards. According to the European Commission (2017d) “this covers approximately 6,000 large companies and groups across the EU”.

There are likely to be complementarities and synergies between different reporting schemes.\(^5\) In providing non-financial information under Directive 2014/95/EU, companies may rely on a range of different national, European (e.g. EMAS) or international (e.g. GRI) frameworks (European Parliament and Council 2014). Also, where companies already need to report emissions under emissions trading systems, it becomes easier to report to CDP or GRI.\(^6\)

### 9.4.2. Changes at the firm level due to external greenhouse gas reporting requirements

Why have companies started to measure and report their GHG emissions? While many companies are subject to mandatory reporting requirements, others report their emissions voluntarily. Sometimes these voluntary disclosures occur on companies’ own initiatives, but often stakeholders also exert pressure on companies to disclose their emissions.

In the following I provide a brief overview of how legal requirements for site level monitoring and reporting, voluntary environmental management schemes,

\(^5\)For example, Lundbeck A/S (in CDP 2015) reports: “Our reporting to the environmental authorities in Denmark has become easier, because they accept our CDP response as climate reporting.”

\(^6\)GRI also invites companies to report on GHG emissions and collaborates with CDP in the continuing development of reporting standards (Global Reporting Initiative and CDP 2011).
and voluntary as well as mandatory standards for corporate GHG reporting have developed. Figure 9.7 provides a timeline of the relevant events.

As mandatory requirements are an obvious factor that is likely to induce the adoption of monitoring and reporting in firms, in the form of mere compliance, the motivations for voluntarily taking up monitoring and reporting require more explanation.

Shell started building early corporate GHG inventories in 1990. Five years after Shell, mining giant Rio Tinto started to build its GHG inventories. This was preceded by the Australian government’s proposal to reduce GHG emissions in 1991. Although the legislation did not come to fruition, this had already increased the salience of the topic (Partnership for Market Readiness 2015, 4).

The IPCC released its GHG inventory guidelines for the country level in 1995 (Intergovernmental Panel on Climate Change, n.d.; Jessica Green 2013b, 137).

In 1997 BP implemented corporate emission level measurements in order to prepare for the introduction of an internal carbon trading scheme in the following year, which allowed it to reap first-mover advantages and levy its experience in policy discussions (Jessica Green 2013b, 138f.; BP 2018).

In 1998 Rio Tinto also established an internal carbon price for its investment decisions (Partnership for Market Readiness 2015, 13). Since then, many companies started using a “shadow” internal price on carbon as a planning tool. This cannot only help to voluntarily reduce emissions but also to already take the potential introduction or further rise of a carbon price into account and thus reduce exposure to regulatory risks. By the end of 2015 437 companies stated to CDP that they use an internal carbon price (Jones 2015).


In February 2002 the Bush administration launched its climate-change policy plan. It indicated that firms that undertake ‘early action’ to reduce emissions would be able to deduct those from future emissions-reduction obligations if, at some point in the future, the government required mandatory emissions reductions via some form of quantitative carbon constraints (Goulder 2002). Hence,

7Unlike Exxon, who stand accused of having tried to bury the evidence for climate change that their own departments had produced and actively promoting doubts about anthropogenic climate change (Gillis and Schwartz 2015), in 1991 Shell even launched a documentary, warning people of the threat of climate change (Carson 2017).
9. Rescoping from firm to product level

Figure 9.7: Timeline of selected events relevant for the rescoping from production to product life cycle GHG information
in the United States, “a]dopting a credible measurement scheme [such as the GHG Protocol] was a way for firms to ... potentially receive credits for reductions made before regulation was enacted” (Jessica Green 2013b, 156). Expectations of carbon constraints have driven firm-level measurement and disclosure standards. Early-movers wanted to make sure they would have a valid way of proving their mitigation actions so that they would not lose out by already depleting efficiency optimisation potential prior to the introduction of regulation (Lyon 2003; Kolk, Levy, and Pinkse 2008; Jonas Meckling 2011a, 95; Jessica Green 2013b, 134).

It was primarily the threat of regulation that led companies to adopt GHG accounting, yet it also provided secondary benefits as it allowed them to flaunt their credentials as good performers and corporate citizens (see also Kolk, Levy, and Pinkse 2008). Green (2013b, 134) suggests that “[a]lthough many GHG programs are voluntary, they are widely viewed as the logical precursor to emissions trading.” Here again, corporate pro-active behaviour towards the development of voluntary carbon reporting and disclosure standards is explained with the anticipation of regulation in the form of mandatory disclosure standards. The quantification of emissions is a prerequisite for trading (Jessica Green 2013b, 134) or taxing them. In retrospective one can also see the quantification of emissions as a precondition for product-level emissions reporting.

Besides anticipated or actual regulation, firms also measure their emissions to satisfy investor demands, as there is increasing investor interest in corporate environmental performance. Investors incorporate carbon criteria into their decisions-making either for moral reasons or in order to reduce their exposure to regulatory, market or reputational risks (Wright and Nyberg 2015, 5, 64).

Investors articulate their demand for corporate-level carbon in two forms. First, they sign up to initiatives like CDP in order to assert that carbon information is investment-relevant and that they have an interest in receiving this information. Second, financial institutions incorporate carbon criteria into their investment strategies (see Table 9.3 for examples). This suggests that companies who do not disclose their emissions may be cut off from such sources of financing.
9. Rescoping from firm to product level

Table 9.3.: Examples of financial institutions incorporating carbon criteria.

<table>
<thead>
<tr>
<th>Organisation</th>
<th>Activity / product</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSCI</td>
<td>Index</td>
<td>MSCI (2018)</td>
</tr>
<tr>
<td>Fonds de Réserve pour les Retraites</td>
<td>French government pension fund</td>
<td>Fonds de Réserve pour les Retraites (2016)</td>
</tr>
<tr>
<td>Fourth Swedish National Pension Fund</td>
<td>Swedish national pension system</td>
<td>Fourth Swedish National Pension Fund (2019)</td>
</tr>
<tr>
<td>ING</td>
<td>Bank lending</td>
<td>ING in CDP (2015)</td>
</tr>
</tbody>
</table>

CDP, formerly the Carbon Disclosure Project, merits a more in-depth discussion here, not least because this section draws extensively on a survey administered by CDP to a large number of organisations. CDP is a, if not the, major player in the corporate climate disclosure movement.

CDP is a non-profit UK-based organisation that makes forceful demands for disclosure by harnessing investors’ power in order to demand from the world’s largest publicly traded companies to disclose their carbon emissions and provide additional information on how they deal with climate change related issues (MacLeod and Park 2011).

The core activity of CDP is that it sends out an annual survey to companies, saves the results in its database and makes it available to interested parties. It has been CDP’s core strategy to recruit institutional investors who can put pressure on companies to disclose their carbon emissions by arguing that they need to have the right kind of information to evaluate the climate-related risks and opportunities of their investments (Knox-Hayes and Levy 2011, 2f.; Jessica Green 2013b, 146).
In 2010 the US SEC issued a new guidance with the recommendation to comprehensively disclose ‘material’ risks associated with climate change and related regulations (Knox-Hayes and Levy 2011, 2). This was an important push for emission disclosure.

How many companies have adopted carbon reporting and disclosure? In 2013 Green (2013b, 144) reported that “roughly 70 percent of S&P 500 firms now report their emissions through the Carbon Disclosure Project”.

9.4.3. Analysis of CDP survey

Let us now examine Proposition 5a: External environmental reporting requirements lead companies to acquire better data on environmentally relevant aspects of production activity.

If the proposition was false, we would expect companies to not indicate that it was correct, as long as there was not a reason for them to make false statements. Therefore, if one can reject the hypothesis that companies do not indicate that environmental reporting requirements lead to data improvements, then Proposition 5a should be confirmed.

I analysed the CDP 2015 survey and hand-coded whether companies indicated data improvements when they described opportunities arising from reporting obligations, or the management methods adopted to harness these opportunities. Table 9.4 shows data improvements due to reporting obligations across regions (only looking at opportunities). Here, and in the following, only regions with at least 10 cases are included. “NA” stands for “not applicable” and represents that I did not find any clear indications of the internal changes under examination. “Yes” represents that I could, indeed, find such indications.

While no South Korean company and only one Japanese company indicated any data improvements due to emissions reporting obligations (at least not in the English language), for all other regions percentages are in the range from 11.8% to 44.4%.
Table 9.4.: Improvement of emissions data as a result of opportunities from reporting obligations, across regions

<table>
<thead>
<tr>
<th>Region</th>
<th>Data improvement</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Region</td>
<td>NA</td>
<td>Yes</td>
<td>Total</td>
</tr>
<tr>
<td>Australia</td>
<td>N</td>
<td>10</td>
<td>8</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Row(%)</td>
<td>55.6%</td>
<td>44.4%</td>
<td>7.1%</td>
</tr>
<tr>
<td>Canada</td>
<td>N</td>
<td>15</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Row(%)</td>
<td>75.0%</td>
<td>25.0%</td>
<td>7.9%</td>
</tr>
<tr>
<td>EU</td>
<td>N</td>
<td>96</td>
<td>18</td>
<td>114</td>
</tr>
<tr>
<td></td>
<td>Row(%)</td>
<td>84.2%</td>
<td>15.8%</td>
<td>45.1%</td>
</tr>
<tr>
<td>India</td>
<td>N</td>
<td>15</td>
<td>2</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Row(%)</td>
<td>88.2%</td>
<td>11.8%</td>
<td>6.7%</td>
</tr>
<tr>
<td>Japan</td>
<td>N</td>
<td>19</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Row(%)</td>
<td>95.0%</td>
<td>5.0%</td>
<td>7.9%</td>
</tr>
<tr>
<td>South Korea</td>
<td>N</td>
<td>12</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Row(%)</td>
<td>100.0%</td>
<td>0.0%</td>
<td>4.7%</td>
</tr>
<tr>
<td>USA</td>
<td>N</td>
<td>40</td>
<td>12</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td>Row(%)</td>
<td>76.9%</td>
<td>23.1%</td>
<td>20.6%</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>207</td>
<td>46</td>
<td>253</td>
</tr>
</tbody>
</table>

Table 9.5 shows data improvements due to reporting obligations across sectors (only looking at opportunities). Percentages of companies indicating data improvements due to reporting obligations range from 0% to nearly 39% across sectors.
9.4. From institutional environment to site and firm level

Table 9.5.: Improvement of emissions data as a result of opportunities from reporting obligations, across sectors

<table>
<thead>
<tr>
<th>Sector</th>
<th>NA</th>
<th>Yes</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Consumer Discretionary</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>39</td>
<td>5</td>
<td>44</td>
</tr>
<tr>
<td>Row(%)</td>
<td>88.6%</td>
<td>11.4%</td>
<td>14.7%</td>
</tr>
<tr>
<td><strong>Consumer Staples</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>17</td>
<td>10</td>
<td>27</td>
</tr>
<tr>
<td>Row(%)</td>
<td>63.0%</td>
<td>37.0%</td>
<td>9.0%</td>
</tr>
<tr>
<td><strong>Energy</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>13</td>
<td>7</td>
<td>20</td>
</tr>
<tr>
<td>Row(%)</td>
<td>65.0%</td>
<td>35.0%</td>
<td>6.7%</td>
</tr>
<tr>
<td><strong>Financials</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>39</td>
<td>8</td>
<td>47</td>
</tr>
<tr>
<td>Row(%)</td>
<td>83.0%</td>
<td>17.0%</td>
<td>15.7%</td>
</tr>
<tr>
<td><strong>Health Care</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>11</td>
<td>7</td>
<td>18</td>
</tr>
<tr>
<td>Row(%)</td>
<td>61.1%</td>
<td>38.9%</td>
<td>6.0%</td>
</tr>
<tr>
<td><strong>Industrials</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>62</td>
<td>9</td>
<td>71</td>
</tr>
<tr>
<td>Row(%)</td>
<td>87.3%</td>
<td>12.7%</td>
<td>23.7%</td>
</tr>
<tr>
<td><strong>Information Technology</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>21</td>
<td>6</td>
<td>27</td>
</tr>
<tr>
<td>Row(%)</td>
<td>77.8%</td>
<td>22.2%</td>
<td>9.0%</td>
</tr>
<tr>
<td><strong>Materials</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>24</td>
<td>1</td>
<td>25</td>
</tr>
<tr>
<td>Row(%)</td>
<td>96.0%</td>
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<td>8.3%</td>
</tr>
<tr>
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<tr>
<td>Row(%)</td>
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<td></td>
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<td>Row(%)</td>
<td>75.0%</td>
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<td>2.7%</td>
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</table>

243
The analysis of responses to the question of whether there are opportunities arising from reporting obligations points to the causal influence external reporting demands have on the emergence of internal environmental accounting.

Here I show only the distribution across sectors and regions for data improvements that were mentioned with regard to opportunities. For risks, I could only identify 12 clear cut instances, which are documented in the Appendix. These contrasts were less drastic in the following analyses, which I report for risks and opportunities together.

Let us now examine Proposition 5c: External environmental reporting requirements lead companies to acquire more expertise on production-based monitoring and disclosure. Similarly to above, the proposition can be confirmed if the hypothesis that companies do not indicate that external environmental reporting requirements lead them to acquire more expertise on production-based monitoring and disclosure can be rejected.

Costs for external consultants and auditors can be regarded as the mobilisation of financial resources towards the building or maintenance of capacities for sustainability accounting with auditors and consultancies, whereas the allocation of resources for internal work builds and maintains such capacities in-house.

Table 9.6 shows that 14.3 to 38.7 % of companies across sectors report human resources allocation as a response to emissions reporting obligations. Table 9.7 shows a range of 0 to 60% across different regions. The regions with the most respondents, EU and the USA, show values around 29%.

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9.4. From institutional environment to site and firm level

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9. Rescoping from firm to product level

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<td>4.8%</td>
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<td>2.3%</td>
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<td>15</td>
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<td>Row(%)</td>
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<td>26.7%</td>
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</table>
9.4. From institutional environment to site and firm level

<table>
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<th></th>
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</thead>
<tbody>
<tr>
<td></td>
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<td>Yes</td>
<td>Total</td>
</tr>
<tr>
<td>Turkey</td>
<td>9</td>
<td>4</td>
<td>13</td>
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<tr>
<td>Row(%)</td>
<td>69.2%</td>
<td>30.8%</td>
<td>2.1%</td>
</tr>
<tr>
<td>USA</td>
<td>81</td>
<td>34</td>
<td>115</td>
</tr>
<tr>
<td>Row(%)</td>
<td>70.4%</td>
<td>29.6%</td>
<td>18.5%</td>
</tr>
<tr>
<td>Total</td>
<td>458</td>
<td>163</td>
<td>621</td>
</tr>
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</table>

Furthermore, interviews with an IBU representative and statements by auditing consultancy Deloitte (2015, 13) suggest that the EU Directive on disclosure of non-financial information and diversity information has increased the demand for employees with the ability to track environmental indicators relevant for these novel reporting obligations. Other consultancies also see the Directive as an opportunity for pitching their consultancy offers (see e.g. Ernst & Young 2017; KERAMIDA 2018).

Let us now examine Proposition 5e: External environmental reporting requirements lead companies to acquire more organisational and technological resources for production-based environmental monitoring and disclosure. Similarly to above, the proposition can be confirmed if the hypothesis that companies do not indicate that external environmental reporting requirements lead them to acquire more organisational and technological resources for production-based environmental monitoring and disclosure can be rejected.

To what extent are reporting obligations associated with specific systems or technologies? Table 9.9 shows the number and percentages of companies that mentioned specific systems or technologies as response to reporting obligations, across regions. Percentages range from 0 to 40%, and between the EU and the US they range between 17.6% and 25.2%.

Table 9.10 shows the same data differentiated across sectors. Percentages range from 8.6% to 26.4%.

---

8In September 2017.

9It is not possible to clearly attribute the valorisation of technologies and systems designed to capture environmental data as the independent variable and the availability of such infrastructure for product-level information as the dependent variable. As one of its response to regulatory opportunities from emissions reporting obligation, the packaging company Huhtamäki Oyj states that “The resources for LCA calculations (working hours, data management systems and software) ... [costs] annually some ...” (in CDP 2015). This statement
9. Rescoping from firm to product level

Regardless of whether the references to the use of ‘systems’ here connote a more or less digital one, they all contribute towards something akin to Environmental Management Systems (EMS).

Many of the actually, or potentially to be, invested sums seem quite significant. For illustrative purposes, Table 9.8 shows some of the higher estimates regarding the costs of monitoring and reporting systems (see Appendix, Section A.2, for the original statements). These sums are sometimes one-off initial investments and sometimes annually recurring.

Table 9.8.: Some of the higher estimates regarding the costs of monitoring and reporting systems

<table>
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<th>Company</th>
<th>Estimated cost of MR system</th>
</tr>
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<tbody>
<tr>
<td>Baker Hughes</td>
<td>$500,000</td>
</tr>
<tr>
<td>Industrial Bank of Korea</td>
<td>$500,000</td>
</tr>
<tr>
<td>L’Oréal</td>
<td>€200,000</td>
</tr>
<tr>
<td>Danone</td>
<td>€2.5 M</td>
</tr>
<tr>
<td>Deloitte Touche Tohmatsu</td>
<td>$1 M</td>
</tr>
<tr>
<td>Dexus Property Group</td>
<td>$300,000</td>
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</table>

Table 9.9.: Companies that mention systems or technologies as a response to emissions reporting obligations (by region)

<table>
<thead>
<tr>
<th>Region</th>
<th>Mentions sys/tec</th>
<th>NA</th>
<th>Yes</th>
<th>Total</th>
</tr>
</thead>
<tbody>
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<td>Australia</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td></td>
<td>27</td>
<td>8</td>
<td>35</td>
</tr>
<tr>
<td>Row(%)</td>
<td></td>
<td>77.1%</td>
<td>22.9%</td>
<td>5.6%</td>
</tr>
</tbody>
</table>

was removed from the count of statements. Here it becomes clear that not all the statements on responses to emissions reporting obligations may refer to production-based reporting but some may already include references to the product level. Insofar, it would be problematic to assume that these statements always refer to one category, in which investment is done in response to emissions reporting obligations, or these technological investment become more useful with additional emissions reporting obligation, and this then can be used to increase information on the product level. Such a neat story becomes undermined by the possibility that some of the technologies and systems mentioned may already be used for product level information.
### 9.4. From institutional environment to site and firm level

<table>
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<td>3.1%</td>
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<tr>
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9. Rescoping from firm to product level

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Table 9.10.: Companies that mention systems or technologies as a response to emissions reporting obligations (by sector)

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<td><strong>Consumer Staples</strong></td>
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<td>45</td>
</tr>
<tr>
<td>Row(%)</td>
<td></td>
<td>77.8%</td>
<td>22.2%</td>
<td>7.2%</td>
</tr>
<tr>
<td><strong>Financials</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td></td>
<td>78</td>
<td>25</td>
<td>103</td>
</tr>
<tr>
<td>Row(%)</td>
<td></td>
<td>75.7%</td>
<td>24.3%</td>
<td>16.6%</td>
</tr>
<tr>
<td><strong>Health Care</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td></td>
<td>32</td>
<td>3</td>
<td>35</td>
</tr>
<tr>
<td>Row(%)</td>
<td></td>
<td>91.4%</td>
<td>8.6%</td>
<td>5.6%</td>
</tr>
<tr>
<td><strong>Industrials</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td></td>
<td>114</td>
<td>22</td>
<td>136</td>
</tr>
<tr>
<td>Row(%)</td>
<td></td>
<td>83.8%</td>
<td>16.2%</td>
<td>21.9%</td>
</tr>
<tr>
<td><strong>Information Technology</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td></td>
<td>44</td>
<td>12</td>
<td>56</td>
</tr>
<tr>
<td>Row(%)</td>
<td></td>
<td>78.6%</td>
<td>21.4%</td>
<td>9.0%</td>
</tr>
<tr>
<td><strong>Materials</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td></td>
<td>48</td>
<td>10</td>
<td>58</td>
</tr>
<tr>
<td>Row(%)</td>
<td></td>
<td>82.8%</td>
<td>17.2%</td>
<td>9.3%</td>
</tr>
</tbody>
</table>
9.5. From site and firm to product level

After having identified significant effects across all three domains of change within companies as part of their response to GHG reporting requirements, one may wish to know to what extent there are likely to be spillovers to the capacity of organisations to create product-level LCA information. Let us first examine the evidence for Proposition 5b: Better data on environmentally relevant aspects of production activity can then be transformed into life cycle environmental data at the product level.

What would be the decisive factor for such a transformability to be either rejected or confirmed? If the proposition is correct, one would expect the hypothesis that LCA analysts draw on data on environmentally relevant aspects of production activity, that were available prior to their analyses but not strictly necessary in lieu of environmental reporting obligations, to create LCAs to be confirmed. If the proposition is false, one would expect the hypothesis that the data required for product-level disclosure is so radically different from that generated by production-based environmental monitoring and reporting that the production-based data cannot be re-used or transformed into product-based data to be confirmed.

The following will look separately at the organisational level, on the one hand, and on the facility or installation level, on the other hand.

Does data recycling from the organisational to the product level lower costs for product level disclosure? This is suggested by the European Commission (2013) when it states that the Organisation Environmental Footprint (OEF),
once “calculated using aggregate data representing the flows of resources and waste that cross a defined organisational boundary ... may be disaggregated to the product level using appropriate allocation keys”. Ernst & Young’s (2012, 1) Eric Duvaud also points out that the different reporting obligations, at the corporate and at the product level, are best addressed with a set of compatible indicators. A DGNB representative, with a specialisation in LCA, also suggested that corporate reporting requirements would help to make data available, which could then be used for LCAs.¹⁰

However, the devil is in the detail. Where do the ‘appropriate’ allocation keys, which the European Commission suggests would be necessary for breaking down the organisational to the product footprint level, come from?

Setting up such a quality model with credible allocation keys requires expertise and effort. Morgan Jones has the impression that “the two disciplines of product footprinting and organisational are still quite separate and the data used rarely crosses over between them.”¹¹ Danny Püschel also asserts that corporate reporting looks at overall resource and energy consumption, and thus has a much lower level of detail than LCA.¹²

Asked whether organisation level data helps much for the production of LCAs, Jane Anderson asserts that, in her experience, LCA practitioners would normally go back into the factory level data to get the production impacts.¹³

We can see that some experts reject the hypothesis that corporate level environmental information could be easily transformed into product level information. The next section looks at whether such a transformation is easier from site to product level.

There is a host of other reporting requirements below the corporate level; that is, at the facility and installation level. There are strong indications that site-level information is indeed very useful for the creation of product-level LCAs: LCI data provider PE International (now Thinkstep) explains that

“Primary data is obtained from specific facilities as a primary source of information. This data is measured, calculated or acquired from

¹⁰Interview in December 2016.
¹¹Personal correspondence, September 2017. Morgan is in a good position to know about the relation between the two disciplines as the Carbon Trust has co-developed the influential product carbon footprinting standard PAS 2050 (BSI 2011; Van der Ven, Bernstein, and Hoffmann 2017) and also offers organisational and product carbon footprinting services (Carbon Trust 2016).
¹²Interview with Danny Püschel in August 2017.
¹³Interview with Jane Anderson.
the bookkeeping of a particular facility.” (emphasis added) (PE International 2013, 55)

Here we can distinguish between three different routes of obtaining data from the site level for the creation of LCAs: separate measurement, direct use of site level data, or the calculation of data based on site level data.

Site level bookkeeping does not necessarily have to be in the form of environmental accounting, in the narrow sense, but can also consist of bills of materials, for example, which are also needed for financial accounting. LCA practitioners use site-level data on raw materials used and electricity. If the data is already available at the facility-level, it should be easier to retrieve the data necessary for LCAs.

But what determines the availability of data there?

From an industry perspective the subcommittee for LCAs of the German Association of the Automotive Industry suggests that companies could take data for the LCA data collection efforts from operational information and documentary systems [such as] Process control systems, ERP-Systems ... Licenses, Emissions statements and surveillance of emissions for plants requiring official approval, ... , Information given to fulfil the laws and/or regulations on environmental statistics, ... , Internal quality and environmental management systems, Environmental reports and statements, ...” (Verband der Automobilindustrie, n.d., 4; Finkbeiner et al. 2003, 380)

They also insist that simplifying the collection of data for LCA is “of utmost priority” (Verband der Automobilindustrie, n.d., 4). This suggests that prior data collection efforts due to environmental regulation or CSR efforts can be usefully drawn upon and facilitate data gathering efforts for LCAs.

For the case of Germany, a senior representative of the IBU states that nearly all, or all, of the required environmental data needed for LCA for the production stage are available via monitoring processes in companies, which need to be conducted in order to be in compliance with environmental monitoring regulations. A particularly important law for this is the Federal Emissions Protection Law (Bundes-Immissionsschutzgesetz (2017)). IBU is an international programme,

[14Interview with Jane Anderson.]
with about 30% of member coming from outside of Germany. For example, in Turkey or in some other Southern European countries, such as Greece and Italy, there was much less data available at some of the production sites. The differences in data availability is probably due to the higher environmental emissions monitoring requirements in Germany.\textsuperscript{15}

Joep Meijer also suggests that the data availability for LCA in (presumably North Western) Europe is much better than in the USA, due to more government reporting requirements.\textsuperscript{16}

External monitoring and reporting requirements help to improve the data basis at the site level and there are significant differences in data availability as a result of differences in such requirements. An example with relevance to climate policy exemplifies this mechanism well: in its EPD for Italian Ceramic Tiles the trade association Confindustria Ceramica (2016, 6) states that

“Emissions of carbon dioxide ... are collected using ETS (Emission Trading System) declaration”.

However, such data is not necessarily directly useable for LCAs. While people running industrial plants may have all the information about the materials and the energy which go in and out of their plants, in LCAs it is regularly a challenge to break the contribution of materials and energy down to the level of the different products.\textsuperscript{17} The data is usually aggregated at a site level and still needs to be disaggregated in order to be allocated to specific production lines within a manufacturing site. This can sometimes make the data useless and it can be easier to measure a specific production line than to try and correctly allocate the aggregated data to the production lines in question.\textsuperscript{18}

Evidence for Proposition H5b, that better data on environmentally relevant aspects of production activity can then be transformed into life cycle environmental data at the product level, is mixed.

There is support for both:

- the hypothesis that LCA analysts draw on data on environmentally relevant aspects of production activity, that were available prior to their analy-
9.5. From site and firm to product level

... ses but not strictly necessary in lieu of environmental reporting obligations, to create LCAs, and

- the hypothesis that the data required for product-level disclosure is so radically different from that generated by production-based environmental monitoring and reporting that the production-based data cannot be re-used or transformed into product-based data.

A priori it seems clear that any additional measurements of hitherto unmeasured environmentally relevant flows translates into additional costs. However, where specific measurements are necessary anyway, the contribution of prior, less specific measurements, may be negligible. Empirical reality is too complex and varied to squeeze it into a clear-cut support or rejection of the proposition advanced. The answer seems to edge closer to a resolute: ‘it depends’. The causal mechanism proposed is one to be reckoned with, but it does not lend itself to be relied upon.

Above, we found good evidence for Proposition 5c that external environmental monitoring and reporting requirements lead companies to acquire more expertise on production-based monitoring and disclosure. Let us now examine the evidence for Proposition 5d, that more expertise on production-based monitoring and disclosure then becomes available for the creation of life cycle environmental data at the product level.

For the purposes here, I differentiate between two kinds of expertise: knowledge about how to conduct an LCA and to work towards certification, and expertise on environmentally relevant flows running through a company or site that can be helpfully provided to LCA experts.

My arguments in support of this proposition are as follows:

1. there is both an organisational and individual overlap in the capacity to offer services related to production-based monitoring and reporting, on the one hand, and LCA, on the other hand,

2. production-based monitoring and reporting provides demand for skills of organisations and individuals who also tend to have

   a) expertise in conducting LCA and creating EPDs and PCFs, and

   b) who can provide helpful advice to LCA practitioners
9. Rescoping from firm to product level

3. growth in the supply of LCA expertise (a) helps to reduce the costs for EPDs and PCFs (this is suggested by Manzini et al. 2006, 128). More people who can provide helpful advice to LCA practitioners (b) should have a similar effect.

In addition to the pure cost-based arguments, one can also make an argument that where production-based monitoring and reporting provides demand for skills of organisations and individuals who also tend to have awareness of LCA/EPDs/PCFs, such greater awareness should help to create demand for EPDs and PCFs.

An interview partner from IBU suggested that there is an individual overlap in the capacity to offer services related to production-based monitoring and reporting, on the one hand, and LCA, on the other hand.\(^\text{19}\) I sought to corroborate that statement by examining the extent of overlap between the fields of LCA and production-based monitoring and reporting. In order to gauge the overlap between the two fields I obtained the specific ‘top skills’ associated with the topic of LCA on the career website LinkedIn.\(^\text{20}\) Figure 9.11 shows the skills. We can see that three of the 14 skills are strongly related to firm level GHG management skills (here indicated by three stars). Where a company employs such staff for firm- or site-specific GHG monitoring and reporting, it should also enjoy spillover effects, strengthening its LCA capacities.

While this does not mean that LCA is among the top skills of those who market themselves as suitable candidates for environmental compliance management and reporting, we can indeed note a significant overlap of skills, as seen from the perspective of the self-proclaimed LCA experts.

<table>
<thead>
<tr>
<th>Table 9.11.: Specific ‘top skills’ associated with the topic of LCA on LinkedIn related to firm level GHG management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific top skills</td>
</tr>
<tr>
<td>Carbon Neutral</td>
</tr>
<tr>
<td>Life Cycle Cost Analysis</td>
</tr>
<tr>
<td>Design for Environment</td>
</tr>
<tr>
<td>Environment</td>
</tr>
</tbody>
</table>

\(^\text{19}\)Interview with IBU.

\(^\text{20}\)https://www.linkedin.com/topic/lca on 28 March 2018
9.5. From site and firm to product level

<table>
<thead>
<tr>
<th>Specific top skills</th>
<th>GHG management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greenhouse Gas Inventory</td>
<td>***</td>
</tr>
<tr>
<td>ISO 14064</td>
<td>***</td>
</tr>
<tr>
<td>Life Cycle Planning Cleaner Production Techno-economic Analysis</td>
<td></td>
</tr>
<tr>
<td>Input-Output Analysis</td>
<td></td>
</tr>
<tr>
<td>Carbon Management</td>
<td>***</td>
</tr>
<tr>
<td>Resource Efficiency Eco-Innovation Sustainable Products Carbon Offsets</td>
<td></td>
</tr>
</tbody>
</table>

There is also an organisational overlap in the capacity to offer services related to production-based monitoring and reporting, on the one hand, and LCA, on the other hand. Figure 9.12 shows the organisations with the most self-declared LCA experts according to LinkedIn data.\(^{21}\) Both Accenture, who has acted as CDP’s ‘Global Digital Partner’, and Ernst and Young indicate that they see opportunities arising from emissions reporting obligations (CDP 2015), and ERM also acts as a GHG emissions verifier (see Table 9.13). Here we can see a clear organisational overlap between GHG emissions reporting and LCA expertise. However, the LinkedIn data is opaque and it was not even possible to store an impression of the webpage in an internet archive.

Table 9.12: Organisations with the most LCA experts according to LinkedIn data

<table>
<thead>
<tr>
<th>Organisation</th>
<th>LinkedIn members</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thinkstep</td>
<td>158</td>
</tr>
<tr>
<td>European Commission</td>
<td>127</td>
</tr>
<tr>
<td>Norwegian University of Science and Technology</td>
<td>108</td>
</tr>
</tbody>
</table>

\(^{21}\)https://www.linkedin.com/topic/lca on 28 March 2018
9. Rescoping from firm to product level

<table>
<thead>
<tr>
<th>Organisation</th>
<th>LinkedIn members</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ernst and Young</td>
<td>103</td>
</tr>
<tr>
<td>Technical University of Denmark</td>
<td>101</td>
</tr>
<tr>
<td>Environmental Resources Management (ERM)</td>
<td>98</td>
</tr>
<tr>
<td>Chalmers University of Technology (Sweden)</td>
<td>90</td>
</tr>
<tr>
<td>Accenture</td>
<td>87</td>
</tr>
<tr>
<td>AECOM</td>
<td>86</td>
</tr>
<tr>
<td>US Environmental Protection Agency (EPA)</td>
<td>84</td>
</tr>
</tbody>
</table>

In 2013 nearly three-quarters of the companies that responded to CDP had their emissions verified by a third party (Confino 2013). This helps to create a market for verification services. Some companies offer both assurance for corporate GHG emissions as well as assurance for GHG emissions and consulting services in the areas of LCAs, EPDs and PCFs. At least three of the ‘big four’ accounting network (Talley 2006, 1643) and professional services firms have started engaging with the field of LCA. As they also engage with corporate reporting, there is a clear overlap between the production and the product level: Deloitte Sustainability Services offers both services for corporate sustainability reporting as well as for the production of LCAs (CDP 2015; Deloitte 2016). Ernst and Young indicates consulting opportunities arising from emissions reporting obligations (CDP 2015) and offers LCA and carbon footprinting services (Ernst & Young 2018). PriceWaterhouseCoopers runs a database on the environmental performance of the cement industry (Cembureau 2015a, 5) and offers LCA services (PwC 2018).

Under the EU ETS emissions need to be verified by accredited or certified parties (European Commission 2015, 83). Amongst a list of nine *Phase III Greenhouse Gas Verifiers* in the UK available from the United Kingdom Accreditation Service (UKAS), seven also offer carbon footprinting services, at

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22The existence of qualified verifiers is not necessarily a pre-given. This is suggested by the Turkish tyre producer Brisa’s (in CDP 2015) complaint that “The lack of accredited bodies (DOEs) in Turkey [for demonstrating compliance with the Regulation on Monitoring of Greenhouse Gas Emissions (see International Energy Agency, n.d.)] may bring additional cost during verification as well as slowing down the process.”
least as part of LCAs and EPDs (see Table 9.13; based on BSI (2011); DNV GL (n.d.); ERM (2009); The International EPD System (2016); Kiwa (n.d.); Lucideon (n.d.); United Kingdom Accreditation Service (n.d.); SGS (n.d.)).

Table 9.13.: Do accredited UK phase III greenhouse gas verifiers offer LCA-based product disclosure services?

<table>
<thead>
<tr>
<th>GHG verifier</th>
<th>Product-level disclosure service</th>
</tr>
</thead>
<tbody>
<tr>
<td>BSI</td>
<td>Co-developed PAS 2050 standard for PCF</td>
</tr>
<tr>
<td>ERM</td>
<td>LCA/PCF</td>
</tr>
<tr>
<td>Bureau Veritas</td>
<td>EPD</td>
</tr>
<tr>
<td>SGS</td>
<td>EPD</td>
</tr>
<tr>
<td>Lucideon</td>
<td>PCF</td>
</tr>
<tr>
<td>DNV GL</td>
<td>PCF</td>
</tr>
<tr>
<td>Kiwa</td>
<td>PCF</td>
</tr>
<tr>
<td>Lloyds</td>
<td>nothing found</td>
</tr>
<tr>
<td>Verifavia</td>
<td>nothing found</td>
</tr>
</tbody>
</table>

Major certification company Bureau Veritas also certifies EPDs (The International EPD System 2016). According to Hoover’s (n.d.), the top competitors for Bureau Veritas are SGS SA, Intertek, and Stiftelsen Det Norske Veritas. All of them, either themselves or companies in their portfolios, offer LCA or product carbon footprinting services (Intertek, n.d.; SGS n.d.).

Major sustainability consultancy and LCA expert Trucost was recently acquired by S&P Dow Jones Indices, who are already involved with using firm-level environmental data for the Dow Jones Sustainability Indices (Robecosam 2018). S&P Dow Jones Indices are part of S&P Global (formerly McGraw Hill Financial). Another division of S&P Global is Standard & Poor’s, one of the ‘big three’ credit-rating agencies. Standard & Poor’s is an actor with major epistemic authority in the financial world, and it is now intimately linked to expertise on firm-level environmental data and LCA.

There is good evidence for a substantial individual and organisational overlap between production-based monitoring and reporting skills and the ability to conduct LCAs. It is thus likely that production-based monitoring and reporting provides demand for the skills of organisations and individuals who also have expertise in conducting LCA and creating EPDs and PCFs.
9. Rescoping from firm to product level

Even if individuals with expertise in production-based environmental reporting do not have sufficient expertise to conduct LCAs and create EPDs or PCFs, they are likely to have a higher awareness of them, which is likely to help the diffusion of EPDs and PCFs by stimulating demand. It would be plausible that consultants and/or verifiers (these can be from the same company) who provide production-related consulting or verification services may point their customers to the possibility to obtain EPDs or PCFs, too. One interviewee drew on their corporate experience to assert that companies who need to comply with corporate environmental reporting requirements have a higher demand for sustainability experts, who then also have a higher awareness of EPDs.\(^{23}\) This is supported by Ibáñez-Forés et al. (2016, 163), who surveyed all 130 companies who had products certified in the International EPD System, the first worldwide EPD Programme, which was launched in 1999. They obtained responses by 55 companies, of which over 50% stated that they found “out about EPD tools through technical consultancy”.

As Tables 9.6 and 9.7 suggest, environmental reporting obligations result in the allocation of staff hours to them. Taking the case of the UK as an example, now companies would tend to have more staff with dedicated environment-related responsibilities, such as an energy manager, or a waste manager, than in the past. This makes it easier to obtain the necessary data when external LCA consultants visit a company.\(^{24}\) This suggests that production-based monitoring and reporting provides demand for skills of organisations and individuals who can provide helpful advice to LCA practitioners.

Above, I found good evidence for Proposition 5e that external environmental monitoring and reporting requirements lead companies to acquire more organisational and technological resources for production-based environmental monitoring and disclosure. Let us now examine Proposition 5f, that more organisational and technological resources for production-based environmental monitoring and disclosure then become available for the creation of life cycle environmental data at the product level.

Manzini et al. (2006, 128) hypothesise that “the greater the sophistication of the company’s technological infrastructure, the lower the EPD costs”. In the following I look more specifically at the technological and organisational infrastructure dedicated explicitly to environmental purposes.

\(^{23}\)Interview with IBU.

\(^{24}\)Interview with Jane Anderson.
20 years ago LCA analysts still needed to deal with physical files and paper invoices. Only some companies had energy data and they usually lacked data on waste and water. Companies had financial data on environmental flows but they would not necessarily know to how much water or how many hours of electricity that would translate. Therefore, LCA consultants needed to extrapolate environmental flow data from financial data. Data availability at the firm level has changed over the last two decades as now many companies have environmental management systems (EMS). Now, environmental data can be easily retrieved from IT systems.25

According to Anderson, by 2005 it was normal that companies in the UK had an EMS. That year the number of European ISO 14001 certificates nearly hit the 50,000 mark, after having more or less doubled within three years (To and Lee 2014, 492). ISO 14001 required companies to implement systems for measuring environmentally relevant flows. Such reporting was not merely financial but companies actually started to record the actual quantities of environmentally relevant consumption and waste production. Historically LCA consultants could not always be sure if company employees used the correct nomenclature when they provided data. Due to the introduction of EMS LCA consultants need to spend less time on checking the correct use of metrics and reconstructing environmental flow data from financial data.26 Consequently, the availability of EMS should have reduced the costs of creating LCAs.

Historically, the lack of an integrated environmental database in companies has been an obstacle to efficient LCA production (Pujari, Wright, and Peattie 2003, 661).27 When environmental data in a company is not centrally available by solely liaising with one person but is widely dispersed and needs to be retrieved from various people, the data gathering for LCAs is more time consuming.28 Today, LCA analysts can take data from centralised environmental management systems (Verband der Automobilindustrie, n.d., 4; Finkbeiner et al. 2003, 380), which have also improved data availability.29

LCA tools such as Thinkstep’s GaBi integrate with IT systems such SAP (Thinkstep n.d.). Thinkstep’s Jane Anderson states that for some of their customers they produce the EPDs directly from their environmental management

25 Interview with Anderson.
26 Interview with Anderson.
27 Interview with Anderson.
28 Interviews with Danny Püschel and Jane Anderson.
29 Interviews with IBU and Jane Anderson.
9. Rescoping from firm to product level

However, LCA software such as GaBi or SimaPro is still distinct from software for corporate level environmental accounting. While there is evidence in favour of the proposition that organisation and technological resources acquired in response to production-based monitoring and disclosure can also be utilised for the creation of life cycle data at the product level (P5e + P5f), it is important to be clear that the systems themselves are still distinct, so that additional elements and skills are needed in order to build on these resources.

9.6. Results and discussion

What have we learned from surveying the evidence for the propositions above?

First of all, Section 9.3 provided some indications that the production of product LCAs is costly, both in general as well as in terms of work time.

I then examined three mechanisms, or channels, by which the institutional environment induces firms to build up data on environmental emissions as well as the expertise and systems to obtain, process and communicate them.

Regarding those propositions concerning the relation between the institutional environment and the level of the firm (P5a, P5c, and P5e) the analysis here suggests that, indeed, requirements for the monitoring and reporting of GHG emissions lead to the build up of data and capacities in companies.

The CDP survey does not comprise standardised questions on the change processes that I examined in-depth. This reduces the probability that there are false positives, which might otherwise arise due to respondents indicating the presence of an effect by accident, or solely because it is suggested by the survey. However, it is likely that respondents may not have indicated such changes due to emissions reporting obligations, even where they happened. Consequently, there is quite a substantial indication that reporting obligations do help to improve capacities in terms of data, systems and expertise.

The low number of statements indicating that data was improved due to monitoring and reporting obligations in the materials sector, however, does mean that the evidence that I have gathered does not very strongly support the proposition for that sector, specifically. Still, when it comes to human resource allocation and the implementation of systems and technologies, the materials sector shows positive indications around 25.4% and 17.2%, respectively.

To what extent can statements made by the diverse set of companies reporting

\[30\text{Interview with Anderson.}\]
9.6. Results and discussion

to CDP be representative of construction product companies that issue EPDs? It could well be that construction product producers would monitor their emissions anyway. It could be the case that construction product producers differ from many other industries due to the importance of energy consumption, which correlateto a certain extent with carbon emissions, and thus makes it more interesting to have data from which carbon emissions can be relatively easily inferred. Or, due to their emissions, they may have been subject to the earlier introduction of monitoring and reporting requirements. However, at least for the case of cement, Vanderborght suggests that in the late 1990s, of about 30 cement companies in the Holcim group, only seven were monitoring their emissions.\textsuperscript{31} While this is only one statement, it suggests that, at least prior to the spectre of regulation arising on the horizon, an important construction-relevant industry did not differ fundamentally from other sectors in that respect.

Capacities can most obviously be strengthened by committing financial or human resources. I show that, at the firm level, production-based reporting requirements have led to the allocation of such resources to the measurement of environmental flows. By establishing or strengthening the monitoring and reporting of environmentally relevant flows as a task within the domain of business, firm-level reporting initiatives have resulted in the building of technical and cognitive capacity within companies themselves and with external consultants.

What about the spillovers of these factors into conditions conducive to the diffusion of product level life cycle information in the form of PCFs and EPDs? The evaluation of evidence for Proposition 5b, that better data on environmentally relevant aspects of production activity can be transformed into life cycle environmental data at the product level yielded an ambiguous result. Indeed, the prior monitoring and reporting of data can often be used for LCAs. However, in many cases the available data is too aggregated, and in order to correctly allocate environmental impacts to individual products it is often necessary to measure individual production lines anew. Despite these limitations, however, there is indeed a rescoping of data from production to product level, even if only to a limited extent.

However, it is important to note that such rescoping depends on the presence of expertise and systems for product level LCA, which links this channel of rescoping to the other ones. It thus becomes clear that this channel does not exist independently of the other ones.

\textsuperscript{31}Interview with Vanderborght, see Section 8.5.
9. Rescoping from firm to product level

In the case of Proposition 5d, that more expertise on production-based monitoring and disclosure becomes available for the creation of life cycle environmental data at the product level, good evidence could be found, but a qualification of the proposition is required. There is a substantial individual and organisational overlap between expertise on production-based monitoring and reporting and LCA. It is plausible that the demand for the first has also helped the diffusion of the second. Yet, overlap does not mean that the skills sets are congruent. Here, further research is needed to better elucidate the evolution of these occupational fields, perhaps by analysing the qualification profiles of sustainability experts to find out more about the extent to which they personify convergence between the fields of environmental compliance, corporate reporting and LCAs. Survey methods could provide additional evidence beyond the opaque LinkedIn data.

It is important to note that the presence of experts on production-based disclosure can help to raise awareness of EPDs and PCFs and be of help to LCA consultants visiting a company. Thus, neither congruence nor overlap would be needed to facilitate the production of LCAs but, in contrast, complementarity can also account for such a facilitation.

There is good evidence for Proposition 5f, that more organisational and technological resources for production-based environmental monitoring and disclosure become available for the creation of life cycle environmental data at the product level. At the firm level it cannot neatly be separated from the prior proposition, as an important part of environmental management systems also consist in the allocation of responsibility for the accounting of environmental flows, which can be of help for LCA practitioners, when they need to gather data in a company. Data availability, the subject of Proposition 5b, is also practically mediated via the retrieval of data through organisational and technological systems, which can affect the speed and thus the costs of LCA production. Yet, corporate level and LCA software is still largely separated.

It seems plausible that better data should be conducive to the diffusion of EPDs/PCFs. If there are less high quality information, they are more dispersed, and less qualified experts around to assemble LCA from them, one would expect that it should take longer for the field to mature to a level that allows EPDs to be used as a basis for policy (keeping expectations towards quality constant) (see also Chapter 7). However, as long as the process is not more standardised and consultants and verifiers, or those institutions choosing the verifiers, have
9.6. Results and discussion

Incentives to provide an easy route towards EPDs/PCFs, which may be less data intensive, it is difficult to conclusively claim that better data availability is a supporting factor for the diffusion of EPDs/PCFs.

One needs to temper expectations that the greater availability of high quality data, and of experts who know how to conduct good LCAs, are drivers for the emergence and diffusion of EPDs. This is only likely to hold true for higher quality EPDs. Goedkoop, an intimate long-time observer of the LCA scene stated that already 20 years ago, with less ubiquitous data, it would have been easy to produce a bad, unreliable EPD. A sustainability consultant and EPD expert stated that in the USA people would be easily satisfied with generic data. Under ISO 14025 it suffices to provide generic information on environmental impacts. The rise of this type of EPD can succeed without much specific data being available. EN 15804 requires more primary data, yet there might still be substantial leeway for EPD producers to rely on generic data (see also Chapter 7).

It seems that the establishment of the institutional responsibilities and procedures as well as that of measuring devices has been more important for supporting LCAs than the availability of firm, facility or installation level data itself. However, the availability of data is closely linked to the expertise and the systems that are required to gather it.

Overall, there is good evidence for the overarching Proposition 5, that production-based environmental monitoring and reporting has spillover effects and thus drives down various costs for eventual product level disclosure of life cycle impacts.

To be fair, it would be difficult to make a case for rejecting the propositions on the basis of the empirical evidence supplied in the hypothesis tests. For even the absence of positive evidence for spillover effects would not necessarily imply that the spillover effects themselves do not exist. One could have more trust in these results if there was a better way to test for the absence of spillover effects. The existence of the evidence, however, strengthens the case that these effects do make a difference. A future academic debate on this issue would most effectively not centre on the absence or presence of such effects but on their relative causal import.

There are probably other factors besides costs that limit the diffusion of LCAs.

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32 Interview with Goedkoop.
33 Interview with Meijer.
9. Rescoping from firm to product level

and EPDs, and which could be mitigated by production-based environmental monitoring and reporting. I already discussed awareness of EPDs by those with expertise in environmental monitoring and reporting as one such factor. Another factor might be that companies who already need to monitor and report environmental data, and who need to share data with third parties for verification purposes, may also become more open to the sharing of product-based data. This, and other potential spillover effects, could be avenues for further research, whose pursuit may eventually help to more firmly grasp the specific contributions of the mechanisms proposed and examined here.

The study here could be usefully complemented by ones which compare the proliferation of production-based environmental reporting and monitoring and product-based LCA disclosure across sectors, regions and over time. However, there would be an important limiting factor for deducing from any such correlations that the causal mechanism of rescoping would be responsible. Manzini et al. (2006, 128) hypothesise that “the more the company’s strategy is oriented toward a green approach, the more the benefits that can be obtained through the EPD”. Companies subject to a high degree of production-based environmental reporting and monitoring may simply be more exposed to other factors, such as consumer exigencies, that could well explain such correlations.

One can clearly see that the data basis for the empirical analysis in the first part was much broader than in the second part. This is mainly due to the greater maturation of the field and the existence of the CDP survey. The emerging PCF/EPD field is much smaller; and I have interviewed representatives from some of the leading organisations in the field. Further research could extend the number of interviews and provide a better coverage of more actors in the field, some of which I have pointed out in my analysis.

I chose to analyse the Investor CDP dataset 2015, as it comprised the greatest number of large companies at the time. An alternative research strategy could have been to trace the statements by selected companies over time. This might help to better understand how companies responded to earlier waves of monitoring and reporting obligations. I may have missed some of this richer, historical information by solely focussing on the more recent dataset.

In addition, due to the complementarities between production based monitoring and product-based disclosure, there may also be a reverse causal effect where product-based disclosure supports the conditions for production-based monitoring and disclosure. While this effect may have been absent or negligible
in the past, it may become more important in the future.

It is important to be aware of the difference between disclosure and regulation (be it by pricing or absolute quantitative restrictions), on the one hand, and monitoring, on the other hand. While some degree of monitoring will be necessary for disclosure and regulation, monitoring can also occur by itself. Regulation and disclosure can, however, be seen as strong drivers for monitoring, and we should not automatically assume that monitoring would occur anyway, even in the absence of these drivers.

In the absence of such automatic monitoring, any critique of disclosure and regulation should, 

\textit{ergo}, take into account the effects they have as drivers of monitoring, and the improved conditions such monitoring is likely to offer for the diffusion of EPDs and PCFs, and therefore for eventual policies that could draw on them.

I do not disagree with critiques of the symbolic, and environmentally ineffective aspects of environmental management systems (EMS) (Ferrón Vilchez 2017) and carbon disclosure (Wright and Nyberg 2015). What my findings, however, contribute to the discussion is the strong probability that the adoption of systems for environmental accounting, such as is promoted by EMS and carbon disclosure, can lower costs for the creation of EPDs. These, in turn, offer novel possibilities for regulation. Even purely symbolic, legitimacy seeking behaviour of companies may thus yield very material consequences.

Another potential spillover mechanism, leading from production- to product-based disclosure of environmental impacts, which I have not tested here, would be that of the emergence of an instrument constituency. Here, an increase in the demand for certain skills creates jobs for people specialised in environmental issues, who may then go on to push for expanding the range of activities within their remit.

Propositions 5c and 5d concern the importance of expertise for both production-based monitoring and disclosure and life cycle environmental data at the product level. While I have solely explored the question of expertise from a functional perspective, in which there may be spillovers concerning the joint utility of expertise, another plausible mechanism by which expertise comes into play could be one that has the agency of experts at its core. Where experts have specific skills and expertise, they may be eager to expand the domain of tasks that require such ‘assets’.

Figure 9.8 sketches out a conceptualisation where investors, public opinion
and regulation provide for exogenously determined motivation to monitor and disclose environmental data. In contrast, I conceptualise endogenous motivation as split between an intrinsic motivation based on values and an extrinsic motivation based on the career advantages that can be had from expanding the domain of activities that corresponds to a specific set of skills and expertise. Such endogenous motivation would be the basis for an ‘instrument constituency’ within the firm (on the concept and theory of instrument constituencies see Voß and Simons 2014 and Section 3.4).

Taking into account the different layers of production-based environmental monitoring and reporting, it becomes difficult to make general statements about the effect of any one layer on the conditions for product level disclosure. Singling out a particular layer without taking into account its relation to other layers runs the risk of being arbitrary and neglecting the relationships among the different layers. For instance, we have seen that the anticipation of carbon policy was a major driver for the private adoption of the GHG Protocol. The anticipation of carbon policy also provided a rationale for investors to demand from firms to disclose their carbon emissions to CDP. There are synergies between the adoption of CDP and GRI, with the costs of extensive reporting under these frameworks even lower when companies have extensive mandatory reporting obligations any-
way. Lastly, a European Directive on non-financial statements could layer onto voluntary reporting such as that under GRI. These dynamic relations between mandatory and voluntary reporting as well as synergies between different reporting purposes make it useful to think about production-based monitoring and reporting as a field of forces which is impacted by various and dynamically developing ensembles of requirements and incentives to monitor and report on environmentally relevant activities.

The causal linkages between production-based and product-based environmental monitoring and reporting are far from straightforward. As I remain at a rather general level, and the actual experiences of people involved with the monitoring and reporting of environmental data and the calculation of LCAs are diverse and specific to different situations, some ambiguity remains. Future research could help to do justice to this by focusing on detailed case studies.

9.7. Conclusion

Material, institutional and cognitive pathways for the spillover from capacities for production to product-focused environmental monitoring and reporting are all important. External reporting requirements help to increase the data on environmental flows that is available within companies, and the competences and capacities to work with this data. Indirectly, this also facilitates the availability of data, systems and competences for the creation of information of the life cycle impacts of products. The transformation of production-based data into product life cycle data is not straightforward but requires additional skills, different software, and sometimes data may not be recycled but must be measured anew. However, there is a sufficient overlap of expertise, technologies and organisational structures to conclude that policies and initiatives that induce a greater engagement with environmentally-relevant data at the level of the site or firm also help to lower costs for producing life cycle information on the embodied environmental impacts of products.

After the last chapter made the case that sectoral industrial arrangements in the environmental domain can reduce transaction costs for the creation of sectoral LCAs and EPDs, this chapter showed that mandatory as well as voluntary environmental monitoring and reporting of production activity indirectly help to facilitate the availability of data, systems and competences for the creation of information on the life cycle impacts of products. Accordingly, even those vol-
9. Rescoping from firm to product level

Voluntary initiatives and mandatory policies that lack substantive effects in terms of environmental improvement by themselves may still contribute towards improving the informational conditions for more informationally intensive policies down the road. Similarly, those voluntary initiatives and mandatory policies which seem to be depoliticising, greenwashing or lacking the ability to muster political support, may still contribute towards improving the conditions for policies with radically altered distributive effects, which offer novel possibilities for rallying behind the banner of low embodied emissions, and which help to include a wider array of stakeholders into policy deliberations.

While this chapter has remained at a rather general level with regard to technological devices and has bracketed out energy efficiency obligations, the next chapter shows how energy efficiency requirements can stimulate the diffusion of advanced energy metering equipment, which helps in the creation of PCFs.
10. From energy efficiency inducing policy to product carbon footprints

During my inquiry into the factors that are conducive to the availability of quality life cycle data at the firm level new evidence led me to construct a new proposition I had hitherto not considered:

**Proposition 7 (P7)** Energy efficiency and/or carbon policy indirectly help to generate higher quality carbon footprint data as they stimulate the diffusion of better energy metering equipment

This can be broken down into two sub-propositions.

**Proposition 7a (P7a)** The diffusion of better metering equipment helps to generate higher quality data on the carbon footprints of products

and

**Proposition 7b (P7b)** Energy efficiency and/or carbon policy help the diffusion of better energy metering equipment

The evidence gathered here is more preliminary and less systematic than in the other chapters but it does add an important additional causal link between carbon and energy policy and the governance of embodied emissions.

10.1. Methodology

I present some evidence in favour of the above proposition in the form of interviews as well as secondary and grey literature. I also present some results of an automated quantitative content analysis of the CDP survey, conducted via keyword searches.

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1In the form of electronic correspondence with Morgan Jones from the Carbon Trust.
10.2. Does better metering equipment help to generate higher quality product footprints?

Rohdin and Thollander (2006, 1841) classify the lack of sub-metering as a form of imperfect information. This situation of imperfect information does not only make itself felt when a company tries to improve its energy efficiency, but also when LCA experts seek to attribute energy consumption and thus carbon emissions to products. More detailed energy accounting systems in companies should facilitate breaking down emissions to the product level.

People running industrial plants may have all the information about the materials and the energy which go in and out of their plants, but in LCAs it is regularly a challenge to break the contribution of materials and energy down to the level of the different products. This severely limits the ability to rescope organisational level data to the product level (on rescooping see Section 3.4). However, this endows those technologies, which help to tackle the challenge to break the contribution of materials and energy down to the level of the different products, with the power to facilitate LCA production.

Energy management systems make the allocation of carbon emissions to the product level process much easier. Once one starts measuring energy it becomes easier to measure carbon, too. In order to assess the embodied energy consumption at the product level it is often necessary to add additional technological components, which can, at times, require a lot of work and financial expenses.

Carbon Trust’s Morgan Jones stated that there is certainly better data for PCFs around than 10-20 years ago, largely due to automatic meter reading and sub-metering. This is a kind of data that is more granular, below the organisational or the site level.

Sub-metering provides granular energy consumption data (Thorn, Kraus, and Parker 2011, 8; Glew and Lovett 2014), which improves the ability of energy management systems to track energy consumption and helps to detect potentials for efficiency gains (Navigant Research n.d.).

I triangulated statements from interview partners with extant literature, personal conversations, and correspondence with Morgan Jones, Carbon Trust.

2Personal conversation with Isabela Butnar, University College London Institute for Sustainable Resources, who used to work as an LCA consultant, interviews with Püschel and Meijer, personal correspondence with Morgan Jones, Carbon Trust.

3Interviews with Danny Püschel and Joep Meijer in 2017.

4Correspondence with Morgan Jones, Associate Director of the Carbon Trust, September 2017. Disclaimer: Based on this interview result, I derived the propositions examined in this section.
10.2. Does better metering equipment help to generate higher quality product footprints?

which also portrays the lack of sub-metering as a barrier to LCA:

- Garcia-Suarez et al. (2008, 348) lament that “[m]ost businesses do not currently measure and record GHG data at the level of individual products ... In fact, sub-metering of utilities in factories / warehouses etc is rare.” Instead “site level energy data are more readily available than data related to individual product lines or factory machines” (ibid.).

- Reap et al. (2008, 383) note that “[d]ata collection costs [for LCAs] can be prohibitively large, e.g., when submetering must be implemented in an industrial facility ... or when data must be frequently collected to remain relevant (Maurice et al. 2000)” (Maurice et al. 2000).

- Thorn et al. (2011, 7) point out that “[t]raditional LCAs are site-independent, but they could be greatly improved if site-specific data were used”. The availability of energy power monitors and submeters enables analysts to draw on such site-specific data (Thorn, Kraus, and Parker 2011, 8).

- An EPD5 by Allegion (2016) laments that “[s]ub-metering was not available to extract process only energy and water use from the total energy use” and acknowledges that “[s]ub-metering would improve the technological coverage of data quality”.

However, according to Anderson, there may not necessarily be such a big difference in results between sub-metering and alternative approaches.6 An important alternative approach is to rely on mass balances. Yet, sub-metering can help to improve over such methods: in their LCA of shea butter use in cosmetics, Glew and Lovett (2014, 75) had to face a situation were “many other products are processed at the refining factory and many other ingredients are inputted in the formulation stage in addition to shea”. However:

“Sub-metering of equipment is not possible and so estimates of the amount of inputs (electricity and heat, etc) that specifically relate to the shea had to be made using allocation”.

5Note that this EPD is solely in accordance with ISO 14025 but not with EN 15804.
6Interview with Anderson.
In their allocation the LCA experts had to rely on the mass of a product for the allocation of emissions. They conceded that “[g]eneralising that all ingredients were responsible for an equal amount of emissions per kg was therefore an assumption that had to be made but which may be misleading” (Glew and Lovett 2014, 79).

The interview results and the extant literature strongly suggests that the availability of sub-metering can make the production of high quality LCAs more affordable. Where sub-metering equipment is already installed for energy efficiency purposes, measuring for LCA purposes can then draw on this equipment. However, it is not clear whether this had a significant effect on the diffusion of EPDs. Perhaps there is sufficient leeway in LCA practice that, in the absence of sub-metering, practitioners would simply make do with less primary data and rely more on modelling. However, where expectations towards data quality rise, this should be beneficial for the credibility of EPDs over the mid- to long-term.

10.3. Do energy efficiency and carbon policies help to diffuse energy metering devices?

What has promoted the diffusion of sub-metering equipment? Is there evidence for a clear link between energy and/or climate policy and the diffusion of metering technologies in companies?

Many policies and initiatives seek to improve energy efficiency. In order to improve energy efficiency, these policies often promote energy audits and energy management systems, establishing markets for them (Serrenho, Bertoldi, and Cahill 2015, 11ff.; UK Environment Agency and Department for Business, Energy & Industrial Strategy 2017; Hardcastle 2012; Zind 2013). For example, the EU 2006 Energy Services Directive and the 2012 European Energy Efficiency Directive (European Commission 2013, 3/6) promote energy audits. An energy audit seeks to systematically inspect energy flows of a site, building, system or organisation in order to identify potential energy efficiency improvements (Serrenho, Bertoldi, and Cahill 2015, 4). From here, it may not be a long way to attributing energy consumption to individual products, or components thereof, which should help in calculating PCFs.

7Interview with Püschel.
The use of sub-metering has been increasing (Hardcastle 2012; O’Driscoll and O’Donnell 2013, 55; ABB 2015, 3). It is promoted as a part of energy management efforts, for example by the UK Energy Savings Opportunity Scheme (ESOS) (UK Department of Energy and Climate Change 2015, 21/23), and the US Energy Star initiative (Roskoski, Gilmer, and Hughel 2011, 17; Masanet, Therkelsen, and Worrell 2012, 14). Some observers also see the expansion of green building certification programs like LEED and BREEAM, which incentivise submetering, as a driver for submetering demand (Hardcastle 2012).

It can be expensive to retrofit sub-metering (Galitsky and Worrell 2008, 14). Therefore, initial investment can make a big difference later on.

Overall, grey and secondary literature support the proposition that energy efficiency policy helps the diffusion of better metering equipment.

In the face of carbon regulation or the anticipation thereof, it can be a plausible strategy to improve energy efficiency. The management of risks associated with carbon pricing can also take the form of investments into energy and GHG reduction assessments. The threat of carbon regulation can lead to better assessments of carbon and energy reduction possibilities. This might lead to more detailed monitoring, which then could help to provide more detailed data, which can then facilitate the allocation of carbon emissions to products as part of LCAs.

In order to test the hypothesis that actual or anticipated carbon pricing stimulates the adoption of energy management measures I ran an automated quantitative text analysis on the CDP survey 2015 with the statistical package R (using Wickham et al. 2017). Of the 952 organisations that indicated regulatory risks arising from cap-and-trade or carbon pricing, 44 included the phrases ‘energy management’ or ‘manage energy’ as part of the description of their management method. Here, we can clearly see that a relatively small number of companies indicate energy management as a response to actual or anticipated carbon pricing. Ten companies directly indicated the use of energy monitoring equipment as a response to carbon pricing, indicated by their use of the phrases ‘smart meter’, ‘energy meter’, ‘metering’, ‘advanced meter’ or ‘electricity meter’ when describing their management method.

While these numbers are relatively small, it is important to take into account that these responses were not part of any standardised survey items but were given in response to open ended survey questions.
10.4. Discussion

There is good evidence for Proposition 7a, that the **diffusion of better metering equipment helps to generate higher quality data on the carbon footprints of products**. The extent of this facilitation, however, depends on the degree of precision one aims at, and the suitability of alternative methods in any given circumstance.

There is also some good evidence in favour of Proposition 7b, that **Energy efficiency and/or carbon policy help the diffusion of better energy metering equipment**.

Future research could usefully complement the preliminary research here as follows:

1. extend the cross-sectional analysis of the quantitative text analysis of the CDP survey data with a longitudinal analysis, taking all years of the CDP survey into account, and
2. conduct more interviews with specifically these research questions in mind.

10.5. Conclusion

Taking the available evidence into account, one can make a good case that energy efficiency and carbon pricing policies have helped the diffusion of sub-metering devices, which in turn helps to facilitate the production of higher-quality LCAs. Just because consultants say that sub-metering is helpful to them, it does not imply that the rise of EPDs can be attributed to them. However, sub-metering should be a supporting factor for reducing the cost of high quality LCA.

Energy efficiency policies can help to both stimulate the improvement of energy efficiency at the building level, which can help to make the role of embodied emissions more prominent, and the capacities to conduct more detailed energy measurements at the level of industrial facilities, which can help to break down facility emissions to the product level.

This chapter has focused on a specific and crucial pathway from policy over technology diffusion to measurement and knowledge creation, which shows how different policies such as carbon pricing and energy efficiency standards can contribute towards carbon commensuration processes. It thus adds more concrete technological insights to the previous chapter. While it is far from clear whether
and to what extent the availability of advanced energy metering equipment has contributed to the rise of PCFs and EPDs, it may well play a future role in easing their creation and in facilitating the verification of carbon footprints. Consequently, there may well be feed-forward effects from carbon pricing and energy policies, via the improvement of capacities for the creation of PCFs, to the emergence and strengthening of coalitions advocating for embodied emissions policies.

While this chapter and the two preceding ones have looked at the creation of life cycle data by producers, the next chapter looks at the informational sources for background databases of LCIs.
11. From policies and voluntary initiatives to the availability of LCIs

Jede Beobachtung des vom Elektron kommenden Streulichtes setzt einen lichtelektrischen Effekt ... voraus, kann also auch so gedeutet werden, daß ein Lichtquant das Elektron trifft, an diesem reflektiert oder abgebeugt wird und dann durch die Linsen des Mikroskops nochmal abgelenkt den Photoeffekt auslöst.

— Werner Heisenberg, Über den anschaulichen Inhalt der quantentheoretischen Kinematik und Mechanik

Background databases, comprising secondary data, are an important pillar of the emerging EPD regime.\(^1\) Where LCA practitioners can directly access plant-specific or process-specific data, one speaks of primary data. LCA practitioners will not always obtain primary data for all the processes they are modelling but also rely on secondary data, which is taken to represent processes that cannot be directly accessed.\(^3\) LCA databases bundle available secondary data on environmental impacts and make them available for LCA calculations at the level of products.

This chapter examines LCA databases as an important potential link between production-based monitoring and reporting, on the one hand, and product dis-

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\(^1\)Interview with IBU.

\(^2\)In its management guide on carbon footprinting the Carbon Trust suggests using ‘baseline’, i.e. *generic*, data from the Carbon Trust Footprinting Company itself or from databases such as Ecoinvent and GaBi (Carbon Trust 2012, 15).

\(^3\)Secondary data may also be termed ‘generic’ data.
11. From policies and voluntary initiatives to the availability of LCIs

closure, on the other hand. How have these databases come about? What are the conditions for their data collection efforts to flourish? What are the links between production-based monitoring and reporting and the availability of secondary data in LCA databases?

The following section lays out the theoretical framework and the propositions for this chapter. After a brief summary of this chapter’s methodology in Section 11.2, Section 11.3 provides an overview of the main LCA databases. Section 11.4 inquires into the public sources of LCA databases. Amongst these data sources emission limits and emission factors are particularly important. Section 11.5 deals with emission limits and Section 11.6 with emission factors. Section 11.7 shows the important role data from or for environmental standard-setting processes has played for the availability of LCIs. Section 11.8 shows how even incomplete, unreliable and heavily extrapolated data can be valuable for purposes of cross-checking and triangulation. Section 11.9 shows how the availability of data derived from legal limits or benchmarking exercises allows LCA database providers to make plausible ‘conservative’ estimates about the environmental impacts of production, which can then be used to elicit more data from better performing companies. In this way, publicly available data can be leveraged to obtain more data, thus potentiating the impact of the original data provision.

11.1. Theory and proposition

The use of publicly available data by the providers of LCI databases constitutes another channel for the rescoping from production-based environmental monitoring and reporting to the product-level disclosure of environmental impacts. LCI database providers can layer onto those institutions that provide environmentally relevant production-based data to the public in order to offer foundations for product-based data. Furthermore, database providers use strategic interactions with producers to elicit more information. This helps to potentiate the value of publicly available information.

In the following I examine this proposition:

**Proposition 8 (P8) Production-based monitoring and reporting has significantly contributed towards the availability of data in background databases**

This proposition has a series of interconnected sub-propositions, for which this chapter will provide evidence.
11.2. Methodology

Proposition 8a (P8a) Technology-based standard-setting in environmental policy has provided data for LCA background databases

Proposition 8b (P8b) Environmental company reports have provided data for LCA background databases

Proposition 8c (P8c) Industry associations have provided data for LCA background databases

Proposition 8d (P8d) Imperfect data can be used by LCA database providers to elicit more data from industry

Proposition 8e (P8e) Imperfect data can be used by LCA database providers to triangulate with other data and thereby arrive at better data

Figure 11.1 provides an overview of the interactions among the sub-propositions.

11.2. Methodology

Based on interviews and document analysis I reconstruct how different production-based environmental monitoring and reporting mechanisms have contributed to the availability of LCIs in databases.

11.3. LCA databases

Since the early 1990s growing demand for life cycle information, mostly from Northeast Asia, North America, and Western Europe, led to the proliferation of LCA databases (UNEP/SETAC Life Cycle Initiative 2011, 38). PRé’s SimaPro, which comes standard-wise with the Ecoinvent database, and GaBi, offered by Thinkstep, are the two market-leading LCA software suites. Both have been on the market for more than 20 years (Ciroth 2012, 151).

In the late 1990s several public LCA databases already co-existed in Switzerland. Eventually, a group of Swiss federal offices began to harmonise and consolidate the different databases and launched Ecoinvent in 2003 (Ecoinvent n.d.).

In 1989 the Department of Life Cycle Engineering at the University of Stuttgart (n.d.), Germany, began working on the development of LCI databases. Soon, the private company PE International, now Thinkstep,
From policies and voluntary initiatives to the availability of LCIs

Technology-based standards

Company reports

LCA databases

Triangulation

Imperfect data

Conservative estimates

Industry

Industry associations

Figure 11.1.: Overview of sub-propositions supporting the claim that production-based monitoring and reporting has significantly contributed towards the availability of data in background databases

spun off and the two entities have continued to collaborate in the development of the GaBi database software. Both partners would later be among the founding members of the German Sustainable Building Council (see Section 6.4.3).

GaBi has tended more to the industry side whereas Ecoinvent is more popular with the research community (Wolf 2014, 7). Ecoinvent’s greater modularity and transparency is probably the reason why it is more popular with the research community. Ecoinvent provides data at both disaggregated unit processes (UPR) and aggregated system processes (LCI) levels whereas most datasets in the GaBi database are not provided as disaggregated unit process (UPR) but only as aggregated process data (Prox 2016b). Interview with Mark Goedkoop in August 2017.

GaBi stands for “Ganzheitliche Bilanz,” which in German means Holistic Balance.

Datasets on the disaggregated unit process level provide the maximum of transparency (UNEP/SETAC Life Cycle Assessment).

Interview with Mark Goedkoop in August 2017.
11.4. Where does the data in LCA databases come from?

Industry associations often do not like to provide unit process data. Confidentiality requirements by those whose processes are examined may then require the aggregation of data (UNEP/SETAC Life Cycle Initiative 2011, 14).²⁶

Where does the data in LCA databases come from? By looking at the data sources underneath the LCI databases provided by Ecoinvent and GaBi, one can establish links between government policies and the availability of life cycle data on certain materials.

Ideally, one would go to a representative number of plants oneself and rely entirely on primary data collection. However, resources for such primary data gathering are limited.²⁷ For background, or secondary, data, often data from the literature or trade organisations are used (European Environment Agency 1997, 59).

Ecoinvent sometimes seeks to obtain primary data via direct contact with individual producers but mostly with industry associations, for example those for plastic and aluminum (see also Section 8.3 on such data provision by industry associations). One advantage of working with industry associations is that they have the financial resources, the people and the knowledge to be competent partners in the creation of LCIs.²⁸

Based on primary documents (Kellenberger et al. 2007; Althaus et al. 2007; Classen et al. 2009; PE International 2013, 55), interviews, and email correspondence with Ecoinvent (December 2017) I could establish that both databases rely on the, non-exhaustive, list of data sources in Table 11.1.

The availability of some of these data sources could, in principle, be reasonably conceptualised as independent from wider trends in production-based disclosure. In contrast, a number of other sources depend very much on wider trends in production-based monitoring and reporting. Government statistics comprises a rather diverse group, of which one cannot make general statements. In the following I will first focus on the sources more obviously dependent on wider trends in production-based monitoring and reporting, and a number of others,

²⁶Interview with Goedkoop.
²⁷Interview with Ecoinvent in December 2017.
²⁸Interview with Ecoinvent.
11. From policies and voluntary initiatives to the availability of LCIs

to then come back to those sources, which, just for the argument’s sake and for the moment, we consider as independent from such wider trends.

Table 11.1 shows the simple dependence of LCA data sources on wider trends in production-based disclosure. Here, simple dependence denotes whether a data source is directly dependent upon prior production-based disclosure. If it is independent, it can be available without prior production-based disclosure. If it is dependent, it requires prior production-based disclosure activity to become available. Here I use disclosure activity in a rather broad sense, not only including self-disclosure but also the publication of average emissions by public authorities. I use the term simple dependence, as there is good reason to assume that the availability of data, which is dependent on production-based disclosure, may also be conducive to industry being more forthcoming with product data. Through such a more complex and dynamic process the publication of product-level data may de facto be dependent on production-based disclosure, too. I call this complex dependence. Such complex dependence will be taken up, again, in the discussion section.

Table 11.1 also features company reports, which overlaps with Chapter 9. While the driver of change is the same in both cases, the prior chapter looks at a rescoping from company reporting to the availability of primary data at the product level, whereas this chapter looks at rescoping towards secondary data for the product level.

Table 11.1.: Simple dependence of LCA data sources on wider trends in production-based disclosure

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<th>Simple dependence on wider trends in production-based disclosure</th>
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<tbody>
<tr>
<td>Independent Primary data collection</td>
<td></td>
</tr>
<tr>
<td>Independent LCA/LCI/EPD studies</td>
<td></td>
</tr>
<tr>
<td>Independent Information from industry sources</td>
<td></td>
</tr>
<tr>
<td>Dependent Company reports</td>
<td></td>
</tr>
<tr>
<td>Dependent Emission permits</td>
<td></td>
</tr>
</tbody>
</table>

284
11.4. Where does the data in LCA databases come from?

Simple dependence on wider trends in production-based disclosure

<table>
<thead>
<tr>
<th>Data source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent: Publicly available documents by environmental agencies from the EU (in particular IPPC BREF reports) and USA (in particular AP-42 emission factors)</td>
</tr>
<tr>
<td>Mixed: General government statistics</td>
</tr>
</tbody>
</table>

The collection of primary data for LCI databases has essentially the same requirements as the collection of primary data for product-specific LCAs, apart from the, ideally, greater number of sites, which should be included in a sample to increase the representativeness of the data. Therefore, many of the same considerations in terms of the conditions for facilitating such primary data gathering should apply, in terms of an informational rescoping from the focus on production to that of the product, as analysed in Chapter 9.

Table 11.1 shows a direct link between the environmental reports of companies and the availability of secondary data in LCA databases. The question arises whether this kind of data is directly at product level or at company level. For example, the CSI led to companies presenting benchmarking data in their sustainability reports (on the CSI see Section 8.5). One of their members, Holcim (2014, 33), provides not only overall emissions data but also data for grams of CO$_2$ emissions per ton of cementitious materials. Mark Goedkoop of the PRé sustainability consultancy concedes that when they collect data for LCA at product level they can sometimes use corporate reports, particularly where a company specialises only in a specific product. However, he is quick to point out that usually a company makes many more things than just the product in question.

There is also a type of circular movement, where LCA databases inform EPDs and EPDs are then integrated into LCA databases. As this helps to generate more data, against which one can cross-check other information, this should also help to elicit more data from industry.

Another important source for LCI databases are publicly available documents

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9Interview with Vanderborght.
produced by government agencies. In order to reconstruct some of the underlying factors, which facilitated the rise of LCAs, and thus EPDs and carbon footprints, it can be helpful to go back in time, to an era before massive LCA databases were readily available, or where coverage of those available was far less comprehensive. This will also help to understand the development of these databases themselves, as they ‘stand on the shoulders of giants’ (Newton 1675).

For example, a 1995 US EPA guide on Public Data Source for the LCA Practitioner suggests that secondary data “are publicly available data which have not been collected specifically for the purpose of conducting LCAs” (U.S. Environmental Protection Agency 1995d, 3). Paradoxically, this definition would exclude those data in contemporary LCI databases, which have expressly been collected in order to facilitate LCAs. However, the definition highlights an important point: publicly available data has been generated without the specific purpose of conducting LCAs and, as a side-effect of whatever led to their collection, it is now available as secondary LCA data. Table 11.2 shows some of the data sources with the specific policy purposes for which they were collected. Rather than accessing data which has been specifically prepared for LCA practitioners in collaboration with industry, a function which is nowadays performed by the likes of Thinkstep, the 1995 EPA guide suggests that in order to fill primary data gaps, “[p]ublic data sources are typically used by LCA practitioners” (U.S. Environmental Protection Agency 1995d, 4).

While the authors of the EPA guide acknowledge that not all of their listed sources are tried and tested as useful for LCA practitioners, it remains striking that many of the listed databases provide information whose generation was stimulated by specific environmental policies.

<table>
<thead>
<tr>
<th>Data on</th>
<th>Database</th>
<th>Data collection purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water pollution</td>
<td>304-(i) Progress Tracking System</td>
<td>Tracking progress of implementation of 304(I) of the Clean Water Act</td>
</tr>
<tr>
<td>Air emissions of criteria</td>
<td>Aerometric Information Retrieval System</td>
<td>Federal regulations</td>
</tr>
<tr>
<td>pollutants from point sources</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 11.2: Public data sources recommended by 1995 EPA Guide
11.4. Where does the data in LCA databases come from?

<table>
<thead>
<tr>
<th>Data on</th>
<th>Database</th>
<th>Data collection purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accidental chemical releases</td>
<td>Accidental Release Information</td>
<td>Non-regulatory approach to improve chemical process safety</td>
</tr>
<tr>
<td></td>
<td>Program</td>
<td></td>
</tr>
<tr>
<td>Air pollution</td>
<td>Best Available Control Technology/Lowest Achievable Emissions Rate Information System</td>
<td>“technology development and environmental compliance permitting”</td>
</tr>
<tr>
<td>Hazardous waste</td>
<td>Biennial Reporting System</td>
<td>Reporting by hazardous waste generators</td>
</tr>
<tr>
<td>Effluent discharge</td>
<td>Effluent Guidelines Studies</td>
<td>“Develop technology-based regulation”</td>
</tr>
<tr>
<td>Air pollution</td>
<td>National Air Toxics Information Clearinghouse</td>
<td>“state and local air toxics program evaluation, regulations and standards, and trend monitoring”</td>
</tr>
<tr>
<td>Sewage discharge</td>
<td>Ocean Data Evaluation System</td>
<td>“Environmental compliance, risk assessment, trend assessment”</td>
</tr>
<tr>
<td>PCB waste</td>
<td>PCB Activity Data Base</td>
<td>Environmental compliance</td>
</tr>
<tr>
<td>Waste water discharges</td>
<td>Permit Compliance System</td>
<td><em>Inter alia</em> environmental compliance and enforcement</td>
</tr>
</tbody>
</table>
11. From policies and voluntary initiatives to the availability of LCIs

<table>
<thead>
<tr>
<th>Data on</th>
<th>Database</th>
<th>Data collection purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toxic chemical releases</td>
<td>Toxic Chemical Release Inventory System</td>
<td>“Industry oversigh, risk assessment, compliance/enforcement, trend monitoring”</td>
</tr>
</tbody>
</table>

17 years later, in her *Life Cycle Assessment Handbook*, EPA official Mary Ann Curran (2012, 118f.) recommends a range of EPA-provided data as sources for developing LCA data sets. Again, she mentions the TRI, and data from technology standard processes. In addition, she also includes the *Compilation of Air Pollutant Emissions Factors AP-42* and the *EPA Sector Notebooks* in her list.

The US TRI can be a useful source of information for analysts conducting LCAs (U.S. Environmental Protection Agency 2006). For example, Hendrickson et al. (1997, 177) derived emissions coefficients from TRI data for their environmental input-output (EIO) LCA. They note that the TRI has various limitations but assert that “it is the most comprehensive toxic chemical release reporting system in the US, and it constitutes valuable public information” (Hendrickson et al. 1997, 180). Joshi (1999, 103) also reports that TRI data have been drawn upon in EIO-LCA. However, the use of the TRI for LCA is limited as there is no clear allocation of waste discharges to individual products. Also, the level of certainty required for LCA may be greater than for the TRI (U.S. Environmental Protection Agency 1995c, 2–10).

There are two particularly important routes by which governments indirectly support LCA creation by analysts external to the industry: first, the fixing and publication of emission limits. Second, the provision of documents on BATs and the fixing of standards based on these techniques. Both routes have led to the creation and publication of emission factors.

11.5. Emission limits

In the US, the Clean Air Act (CAA) revision of 1990 introduced a system requiring all industrial air emissions sources to obtain emission permits from the

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10Reasonably Available Control Technology / Best Available Control Technology / Lowest Achievable Emissions Rate (RACT/BACT/LAER) Clearinghouse (RBLC).
11.5. Emission limits

states. In addition, the CAA introduced residual enforcement by the Environmental Protection Agency (EPA) and citizen litigants (Hays 1998, 531). Since then, each stationary source, regardless of what it emits, needed emissions permits. Section 504 of the CAA stipulates that “[e]ach permit ... shall include enforceable emission limitations” (United States Code 2013).

In the 1980s Germany was, at least subjectively, hit hard by the ‘Waldsterben’ (the ‘dying of the forest’) (Ulrich 1990). The government felt pressure from both forest interests and from the strong environmental movement, with the Green party having freshly entered parliaments, and decided on ambitious clean-air policies. With the intention to avoid that these policies would harm the competitiveness of German industry, the government lobbied successfully for the harmonisation of European emissions control policy. The third Environmental Action Programme (EAP) (1982 - 1986) duly emphasised the linkages between the internal market and environmental policy, particularly focusing on the need for policy harmonisation in order to avoid distortions to industry competitiveness. On the one hand, this led to considerations of the importance of harmonising product regulation in order to avoid that different national product norms would result in non-tariff barriers to trade. This is amongst the origins of the European Commission’s concern with LCA-based product norms (as alluded to in Section 8.3). On the other hand, this re-orientation of the EAP resulted in a shift from an environmental quality to an emissions-oriented approach, with proposals for the formulation of emissions limit values for both mobile and stationary sources (Hey 2005, 19f.).

Historically, pollution control in many countries has been based on a procedure whereby the operators of industrial installations have to apply for emission permits, which set maximum allowable emissions for (single) regulated pollutants (Gray, James, and Dickson 2007, 69). Going beyond this, the fourth EAP (1987 – 1992) focussed on an ‘integrated’ approach (Hey 2005, 20f.).

In the UK, the Environmental Protection Act of 1990 adopted such an ‘integrated’ approach to pollution control (IPC), whereby not just single pollutants should be considered in permitting decisions but the combined impact of pollutant releases on the three environmental media of air, water and land (Gray, James, and Dickson 2007, 69f.).

In the EU, the 1996 IPPC Directive established that permits for industrial installations should fix emission limit values for pollutants (or provide equivalent parameters or technical measures) (Pallemaerts 1996, 175). Emission limit
values from emissions permits are a valuable sources for the creation of LCIs (see Table 11.1). The utilisation of these emission limit values for the creation of LCIs is a channel for rescopying of environmental information from the production to the product level.

It is not clear to the present author, to what degree the IPPC Directive has increased the publication of emission limit values in Member States or whether it has simply mandated practices that were already prevalent at Member State level. However, we can conclude that, at the very least, the IPPC Directive made sure there was a kind of backstop, guaranteeing that even if the Member States did not want to or would have liked to reverse the publication of emission permits, they were legally obliged to make emissions limit values for industrial installations available.\footnote{The publication of emission limit values is, of course, predicated on the existence of the emission limit values themselves. Wöckel (2008, 56) suggests that it would be contrary to EU law to exempt all industrial installations from emissions limit values.}

### 11.6. Emission factors

Once emission limits are set as parts of permits, it must be possible to monitor compliance. This requires ways of estimating emissions. The US Air Quality Act of 1967 authorised expanded studies of air pollutant emission inventories (U.S. Environmental Protection Agency, n.d.c). The CAA, much of which basic structure was established by the US Congress in the CAA amendments of 1970 (U.S. Environmental Protection Agency 2013), requires EPA to set emissions standards or limits for air pollution sources such as industrial facilities. In order for EPA to be able to fulfil this role, it provides “EPA [with the] authority to collect data from industries on emissions, control technologies and costs” (U.S. Environmental Protection Agency, n.d.d). During this work the EPA has generated a wealth of publicly emissions factors.

The compilation of emissions factors is needed as direct emissions measurements have often not been available to the extent necessary for entirely relying on them. The EPA (1995b, 1) points out that

> “Data from source-specific emission tests or continuous emission monitors are usually preferred for estimating a source’s emissions because those data provide the best representation of the tested source’s emissions. However, test data from individual sources are
11.6. Emission factors

not always available and, even then, they may not reflect the variability of actual emissions over time. Thus, emission factors are frequently the best or only method available for estimating emissions, in spite of their limitations.”

Figure 11.2 is taken from the AP 42 manual (U.S. Environmental Protection Agency 1995b, 1). It shows that continuous emissions monitoring (CEM) is the most expensive yet also the most reliable way to estimate emissions. It is deemed as reliable, and potentially more reliable, than the best AP 42 emission factor. Some of the other estimation methods show a greater variability in the extent to which they are more or less reliable than emissions factors, depending on the context.

The EPA has been publishing its *Compilation of Air Pollutant Emission Factors (AP-42)* since 1972. AP-42 emissions factors are supposed to be representative of existing conditions and should not be confused with normative standards.
11. From policies and voluntary initiatives to the availability of LCIs

(U.S. Environmental Protection Agency 1995b, 1). By now AP-42 contains emission factors for more than 200 air pollution source categories (U.S. Environmental Protection Agency, n.d.a).

Reports from the IPPC process are a very important source for Ecoinvent, and without this process it would be much more difficult to get data for a range of industries. The IPPC BREF’s for such varied areas as the production of pulp and paper (European Commission 2001, ii), polymers (European Commission 2017b, xxiii), and large volume organic chemicals (European Commission 2003, 8ff.) provide emission factors for environmentally relevant unit processes. However, it can still be a challenge to filter the information in the IPPC reports in order to make them useful for the creation of LCIs, in particular when one wants to come up with estimates for specific countries, as IPPC reports tend to be based on a mix of sites from different countries. When asked how Ecoinvent would have managed to get the data without the IPPC process, the representative immediately started to talk about the situation 20 years ago (the first BREF was accepted in 1999). Compared to today, where better data is available, 20 years ago people would need to rely a lot more on theoretical modelling, assumptions, and direct contacts with producers. However, the Ecoinvent representative was also keen to point out that the IPPC reports are by far not the most important source of information for them.\(^\text{12}\)

11.7. Role of data from or for standard-setting processes

As part of the British IPC, the concept of BATNEEC (BATs not entailing excessive cost) was introduced, which was supposed to form the basis for setting emission limits (Gray, James, and Dickson 2007, 70).

During the fifth EAP (1993-2000), the ideas of the ‘integrated’ approach from the prior EAP became more material. Building on the IPC, in 1996 the European Commission adopted the Integrated Pollution Prevention and Control Directive (IPPC) [96/61/EC] (Gray, James, and Dickson 2007, 70).\(^\text{13}\)

The connection between emissions limits and BATs is rather tangential as, in principle, there could be other yardsticks for fixing emissions limits, and in practice there is a lot of leeway for taking additional circumstances, in addition to the BATs, into account (on the permit conditions see Krämer 2016, 176).

\(^{12}\)Interview with Ecoinvent.
\(^{13}\)See also Section 8.3.
11.7. Role of data from or for standard-setting processes

The IPPC process and the resultant BREFs do play a considerable role in the field of LCA. Let us first look at a symptomatic example: in their *Life Cycle Assessment of Steel Produced in an Italian Integrated Steel Mill* Renzulli et al. (2016, 3) make clear that

“Whenever data was not available, it was estimated via … BREF .. for steel.”

In the well searchable Wiley Online Library there are 975 results for a combination of search terms on life cycle assessment/analysis and those related to Integrated Pollution Prevention and Control. This is 13.1% of the overall number of 7402 results solely for search terms on life cycle assessment/analysis.

How can we understand the relation between BATs and LCA? Because the IPPC process is about integrated pollution prevention and control rather than a focus on one specific pollutant, the deliberation on BATs is multi-criteria in nature. This makes it structurally similar to LCA, which is also a multi-criteria exercise. Not only is LCI data extracted from the BREF documents detailing BATs, one can also use LCA to determine BATs. Nicholas et al. (2000, 202) suggest that “[LCA] can provide the kind of integrated environmental assessment required by the [IPPC Directive]” (see also Yilmaz, Anctil, and Karanfil 2015). For example, Laso et al. (2016, 385) propose the “use of the … LCA .. to identify the [BAT] to the management of the residues generated in the anchovy canning sector”.

In its *General guide for Life Cycle Assessment*, the European Commission’s Joint Research Centre’s Institute for Environment and Sustainability (EC-JRC-IES) (2010, 198) suggests to use BAT reference documents (or BREFs) as a source of data for LCA. Under the EU Industrial Emissions Directive (IED), the IPPC’s successor directive, around 50,000 installations undertaking certain

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14 The search terms were as follows: “life cycle assessment*” in All Fields OR “life cycle analys*” in All Fields AND “Best available techn*” in All Fields OR “Integrated Pollution Prevention and Control” in All Fields OR “BREF Reference” in All Fields OR “IPPC Directive” in All Fields OR “IPPC regulation” in All Fields OR “IPPC Bureau” in All Fields between years 1995 and 2016.

15 The search terms were as follows: “life cycle assessment*” in All Fields OR “life cycle analys*” in All Fields between years 1995 and 2016.

16 The suggestion by the EC-JRC-IES has been duly taken up – transposed from BREF to EU ETS benchmarks. For example, an EPD for Acoustic Partition Roll relies, next to other sources, on background data from the EU ETS (BRE Global 2015a, 2015b).
industrial activities are required to operate under a permit. The permit conditions, as they relate to emissions values, must be based on such BAT. However,

“[i]n order to avoid duplication of regulation, the permit for an installation covered [by the EU ETS] should not include an emission limit value for direct emissions of the greenhouse gases specified in ... that Directive except where it is necessary to ensure that no significant local pollution is caused or where an installation is excluded from that scheme” (European Parliament and Council 2010; see also European Commission 2018; Krämer 2016).

Under the EU ETS products are benchmarked in order to determine the free allocation of emissions permits. This is a prime source of already verified and representative data at the product level. Thus, the product benchmarks under the EU ETS are a close equivalent to a BAT reference. However, the JRC’s BAT references documents still contain information on carbon emissions. The JRC’s BAT reference document on cement it only addresses CO$_2$ on half a page, referring to the framework around the ETS, whereas six pages are dedicated to nitrogen oxides and three and a half to sulphur dioxide. Carbon dioxide is also not addressed under *Techniques to consider in the determination of BAT* (European Commission Joint Research Centre Institute for Prospective Technological Studies 2013). Thus, by now ETS related data should be the best source for carbon dioxide data for LCA.

Mark Goedkoop also points out that mandatory reporting of carbon emissions can provide good data for basic material LCAs, such as aluminium or steel, in contrast to complex companies with a wide range of different products and deep supply chains, such as Siemens. When company reports provide useful data for external LCA analysis, it makes sense that data from the emissions trading systems might also be used for the calculation of LCI data. For example, Ryan Zizzo (in Gies 2018) claims that reporting under the EU ETS in Europe leads to greater data availability on the carbon content of materials produced in Europe.

Amongst the objectives of the information exchange producing the BREFs is the “worldwide dissemination of achievable consumption and emission levels” (Schoenberger 2009, 1526f.). For the elaboration of each BREF document a Technical Working Group (TWG) is set up. In 2009 Schoenberger (2009, 1527) reported that “[t]he number of TWG members varies between 30 and 110 with an
average of 64”. Seven years later, the European Commission’s Joint Research Centre (n.d.) claimed that a “TWG usually consists of between 100 to 200 experts”. Experts are nominated by an Information Exchange Forum, consisting of government, industry and NGO representatives (Schoenberger 2009, 1527).

We can see that the BREF elaboration procedure mobilises a massive number of experts and has the capacity to elicit information from industry as it can frame what technologies are appropriate to use. A similar mobilisation of experts cannot be expected from much less well-funded actors, without much of a clout, like Thinksstep and Ecoinvent. Sometimes LCA database providers only have data for one company and they make that then representative for the sector.\textsuperscript{18} This shows how initiatives like IPPC, where often more facilities are used in order to obtain BATs, could help to improve LCA databases. Whereas Schoenberger (2009, 1528f.) lists a range of uses of the BREFs, yet does not mention LCAs, the IPPC BREF elaboration processes have provided an important data basis for the LCA community and carbon accounting communities.

Member states were also required to report, in the exchange of information, on the emissions limits they set and, if appropriate, from which BAT the emission limit values were derived (Article 16 of IPPC Directive). Crucially, the Directive reserved the option for the Commission to propose community-wide emission limit values if the exchange of information revealed such action to be necessary (Article 18 of the IPPC Directive).

We can see that the IPPC Directive and its successor, the IED Directive\textsuperscript{19}, have been endowed with sufficient clout for incentivising industry to get involved in the process. In response to the IPPC Directive, major EU industrial associations formed the IPPC Alliance (Jacob et al., n.d.; IPPC Alliance 2008), later renamed into Industrial Emissions Alliance (IE or IED Alliance) (Cembureau 2011). According to the European Engineering Industries Association Orgalime (Orgalime, n.d.), the “IED Alliance meets regularly, every three months, and especially before Article 13 Forum\textsuperscript{20} and Article 75 Committee (member states) meetings”. Here we see how government-industry interaction within these arrangements helps to produce information for LCAs to rely on.

\textsuperscript{18}Interview with Mark Goedkoop in August 2017.

\textsuperscript{19}The IPPC Directive was revised in 2008 and, eventually, replaced with the Industrial Emissions Directive (European Parliament and Council 2010).

\textsuperscript{20}“... a forum composed of representatives of Member States, the industries concerned and nongovernmental organisations promoting environmental protection” providing opinions on the practical arrangement of the exchange of information (Article 13 of the IED Directive).
How can LCAs rely on the BREFs? A joint conference paper (Weidema et al. 2006) by LCA consultants and an employee of the European Commission’s Institute for Environment and Sustainability spells out the logic:

“The study intends to model modern, best available technology (BAT), … , modern technology is generally defined as Directive compliant, and taking into account the information provided in the BREF notes.”

EPA also has powers to enforce standards based on the best performers in an industry (U.S. Environmental Protection Agency, n.d.d). Some EPA AP-42 emission factors are also, at least partly, based on the results of studies to support new source performance standards (for examples see e.g. U.S. Environmental Protection Agency 1995a, n.d.b, 2008). Performance standards require data on the pollution levels associated with specific aspects of production. Emissions factors are an important element in both the identification of best performers and the setting of standards. Even if a direct measurement of emissions was possible, standard-setting – unlike taxation or pollution trading – would still require that emissions factors be calculated, compared and benchmarked.

To what extent are EPA and IPPC data used in Ecoinvent and GaBi? I first searched for references to EPA and IPPC documents in Ecoinvent methodology manuals for building products and metals and then searched for equivalent data in the GaBi database to get an indication of the extent to which they rely on such publicly available sources, often derived from standard-setting exercises. One can find considerable references to the IPPC and to EPA in both datasets (see Table A.9 in the Appendix, Section A.12). To the present author, GaBi seemed much less transparent, as there were many references to prior GaBi datasets, which I could not access.

Looking solely for such terms may certainly be regarded as a form of cherry-picking of evidence. To quantify the presence of sources from the IPPC process and the EPA in the Ecoinvent database, Table 11.3 shows the number of pages in which these references occur in a number of methodological reports underlying the Ecoinvent database.
Table 11.3.: Number of pages mentioning the IPPC process or the EPA in Ecoinvent reports

<table>
<thead>
<tr>
<th>Report subject</th>
<th>Pages mentioning IPPC</th>
<th>Pages mentioning EPA</th>
<th>Total no. of pages</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemicals</td>
<td>76</td>
<td>58</td>
<td>957</td>
<td>Althaus et al. (2007)</td>
</tr>
<tr>
<td>Building</td>
<td>36</td>
<td>42</td>
<td>914</td>
<td>Kellenberger et al. (2007)</td>
</tr>
<tr>
<td>products</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metals</td>
<td>187</td>
<td>11</td>
<td>926</td>
<td>Classen et al. (2009)</td>
</tr>
</tbody>
</table>

The scholarly community tends to prefer working with Ecoinvent, which is a more transparent database. Ecoinvent draws a lot on IPPC data. Reliance on such publicly available data makes it easier to exhibit a high degree of transparency.  

11.8. Role of cross-checking or triangulation

The Ecoinvent representative was keen to point out that they would never rely solely on any one publicly available data source for the creation of an LCI but that they would combine and cross-reference data sources.

For a country level average data set, Ecoinvent would combine information from different sources. Amongst these it would be useful to look at emissions registries and corporate environmental reports, in particularly, where these provide site-specific information.

When it comes to company reports, in principle we are observing the same trend as in Chapter 9 on the determinants of data availability at the company level. However, the way in which company reports help to provide data is markedly different from the perspective of LCI compilers, who may not have direct access to company data or seek to generalise from the available primary data with the help of other sources, which they use for cross-checking.

21 Or, perhaps, it was just easier for this author to trace back Ecoinvent data to IPPC data than in the case of the less transparent GaBi.

22 Interview with Ecoinvent.
11. From policies and voluntary initiatives to the availability of LCIs

Ecoinvent insists that they always rely on several data sources, which they cross-check. When it comes to attributing a certain amount of pollution to a good, without information about production volumes the usefulness of facility-level pollution data is limited. However, facility-level pollution data can still help to inform initial rough estimates or to cross-check other data sources.\(^{23}\)

LCIs are obviously far more detailed than what can be found in corporate environmental reporting, such as what is being done in accordance with the GRI. However, when Ecoinvent produces LCIs, they rely on a combination of both bottom-up and top-down approaches, seeking to cross-reference their data. In this process, publicly available information such as corporate environmental reports can be a useful data source, amongst others.\(^{24}\)

For example, Ecoinvent may have data from, for example, the GRI reports of different chemical production sites. Although they know that these sites produce several different types of chemicals, it is still useful for them to know the average electricity, heat, water, etc. use per 1kg of chemical compound produced. They can then refine these values (make them bigger or smaller) using information from other sources.\(^{25}\)

11.9. Benchmarking and the ‘conservative’ approach

The elaboration of BREFs, ETS benchmarking and sectoral EPDs can all be seen as exercises in benchmarking. Whereas BREFs are typically based on a set of installations that were much smaller than the population to be regulated, ETS benchmarking and the elaboration of sectoral EPDs are normally supposed to encompass all entities that are either subject to the free allocation based on the benchmarking or that are meant to be represented by an EPD. Structurally, ETS benchmarking and sectoral EPDs are very similar. Both produce a performance curve. In the case of the ETS, these tend to be published (see e.g. California Air Resources Board 2011, 12ff.), whereas in the case of EPDs often only average values are presented.

Differences in the location on the curve are supposed to have material consequences in terms of ETS, as worse performers need to acquire more emissions permits per unit of output, but for sectoral EPDs those are not present. How-

\(^{23}\) Interview with Ecoinvent.
\(^{24}\) Interview with Ecoinvent.
\(^{25}\) Interview with Ecoinvent.
ever, there may be incentives for better performing companies to publish specific EPDs in order to show that they perform better than the sector average.

Ecoinvent seeks to motivate industry to work with them. Sometimes this is relatively easy, sometimes it is more difficult. Many producers, particularly if they believe they are performing badly, and therefore see data disclosure as a risk, are hesitant to provide their data. If there is not a sufficient level of data coming forward from the industry, Ecoinvent relies on a ‘conservative’ approach, which may mean that they base their estimates on legal emission limits. If an industry wants to show that they perform better than what legal limits imply, they would then be required to share data. According to Anderson, BRE also used a conservative approach when producing life cycle based ratings for the Green Guide (see Section 6.4.2). Then companies would come forth, saying that they actually have a better performance and would provide BRE with confidential data to prove it. This shows the potential importance of processes such as the IPPC, and publicly available emissions limits, as they provide reasonable estimates for ‘conservative’ approaches. It also suggests that data sources, if imperfect, can serve to gain a more holistic picture not just by triangulation but also by serving as conservative values, which can help to elicit more information over time.

We can say that – if there had been an absence of industry self-reporting of GHG data or in the cases where there actually was such an absence – the IPPC and the ETS benchmarking exercises as well as the elaboration of emissions factors by the national GHG inventories, should have helped to provide data for LCI databases. Counterfactually, one can speculate that the absence or presence of the availability of this data, on which LCA calculations could have fallen back in the absence of cooperative attitude of industry, could have made a difference in the inclination of industry to provide data. If plausible data can be plugged into calculations anyway, industry may have more of an interest in providing data, at least in cases where the data shows that industry actually improved its performance.

26 Interview with Ecoinvent.
27 Interview with Jane Anderson.
11. From policies and voluntary initiatives to the availability of LCIs

11.10. Discussion

The evolution of data sources for LCAs mirrors that of environmental policy. Increasingly ambitious environmental policy requires more information and measurements, which then inform life cycle inventories and assessments. The shift from single to multi-media regulation in the sphere of the regulation of production is something which can also be found in the dynamics of the debate on a carbon footprint between the European Commission (2016) and its consultants, which ended in the recommendation that a more holistic measure, such as a Product Environmental Footprint, should be adopted.

We have seen that emissions factors are valuable sources for the calculation of LCIs. Now, this leads to an interesting point: without the *imperfect* measurability of emissions the compilation of emissions factors would not be necessary. Reversing the statements, we could say that the availability of EPA AP-42 emissions factors for the purposes of LCI modelling *depends* on the *imperfect* measurability of emissions. Less ‘friction’ in the informational processes involved in ensuring production-based regulatory compliance would translate into less publicly available data for product-based environmental disclosure.

This ‘friction’ in the informational processes involved in ensuring production-based regulatory compliance is also present in the case of the IPPC. It is precisely this ‘friction’ which helps to bring about an informational surplus that can be drawn upon by the creators of LCI databases.

Consider a counterfactual policy, where emission limits would be set independently of a technology: we could imagine this in the form of a technology-independent emission limit, emissions pricing, or pollution limits related to environmental media, like air quality. In addition, let us imagine that all emissions can be directly measured. In such a case, there would be no need for the elaboration of emissions factors, such as those compiled in EPA’s AP 42. There would also be no need for the elaboration of BREFs.28

Even if emissions factors were still available, without a BAT approach, there would be less grounds for any assumption that emissions could be expected to be accordance with the range of performance associated with the BATs, thus

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28Policy-makers may still find it useful to have BREFs, in order to base pricing structures on them. However, if there was such a decision, this would put into doubt one of the main arguments of the proponents of market-based approaches: the claim that market-based approaches can significantly economise on the information required by regulators (see e.g. Helm 2010, 193).
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making the calculation of LCAs based on secondary data less reliable.

We can see that some of the major sources for LCI databases, and even more when one looks at the historic beginnings of LCA, have benefited from

a. the technological, economic and administrative challenges of measuring emissions directly, and

b. the informational requirements of performance or technology-based regulation.

There is good reason to assume that – in keeping with a remark by Anderson, “more data generates more data”\textsuperscript{29} – without that kind of public information available, companies would have been less forthcoming with offering private disclosure, and also the epistemic basis for LCA studies would be more precarious as it would be less transparent on what sources practitioners draw, if they are not public.

One could very well argue that relying purely on industry-provided data would be a possibility for LCA. However, under such circumstances, the development of the field would be much more up to the goodwill of industry, rather than being supported by the coercive potential of government.

Experts associated with some of the foremost LCA database providers suggest that industry can be rather hesitant in providing detailed data\textsuperscript{30} and that a conservative approach to representing the environmental impact associated with industrial processes, in doubt erring on the side of greater impacts, can help to elicit more data from industry, in particular where they perform better than what the conservative estimates indicate.\textsuperscript{31}

One can observe an, initially non-intended, ‘layering’ of institutions, where institutions designed for regulating the environmental impacts of production form the basis for an improved functioning of institutions designed for assessing the life cycle impacts of products (LCI databases). These databases, in turn, provide a foundation for another institutional layer: EPDs. EPDs, then, promise to enable embodied emissions policies (see Chapter 5).

Whereas BAT and performance standards for sectors promise only efficiency enhancement \emph{within} sectors, the data which is generated by these processes at

\textsuperscript{29}Interview with Anderson.
\textsuperscript{30}Interviews with Pré’s Mark Goedkoop and Ecoinvent.
\textsuperscript{31}Interviews with Thinkstep’s Jane Anderson and Ecoinvent.
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the level of LCAs can help to spur *inter-sectoral* competition in the realm of functional units (see Chapter 5). Were market-based mechanisms at the production-level to do away with the need for this kind of information, they would also fail to provide the information that is needed to construct the framework for consumption-based approaches. Where primary data is not yet available, such purely market-based mechanisms would fail to generate the secondary data that can be plugged into LCA models in lieu of primary data.

Market-based instruments are praised for economising on the information required (Helm 2010, 193). This, however, leads to another kind of dependence of policy-makers on information provided by the regulated: that on information required in order to prevent emissions leakage. In contrast, regulatory instruments that help to elicit more information on the environmental impacts of production can help to establish the informational infrastructure needed to build consumption-based approaches from the bottom up.

Technology-driven emissions limit values require more *ex-ante* information on part of the policy-maker and can be deemed more *dirigiste* than those which solely determine an ‘acceptable’ level of pollution and leave it to the polluters to decide to which extent they will ‘fill up’ the allowable limit (on the problem of “filling up” see Scheuer 2005, 34). Pollution taxes or tradable emissions permits are similarly disinterested in how given emissions levels are achieved, and consciously so. In theory, this does have efficiency advantages. However, we have seen that it was exactly the elaboration of BATs for the purpose of setting emissions values, which has helped to provide important information on the environmental impacts associated with the production of goods. In addition, the expectation that these BATs should form the basis for emission limit values also provides at least tentative reasons for conducting LCAs *as if* one could generalise BAT performance to industrial installations in the European Union.

In order for higher level regulation to be technology-neutral, lower level processes first need to be made commensurable (on commensurability see Section 3.3). One mode of commensuration is the act of making something *representative*. As soon as one can claim that LCIs for products or processes are representative, to a sufficiently high degree, for actual processes in the real world, one can compare their environmental impacts and thus make them *commensurable*. Ironically, the achievement of technology-neutrality at a higher order level, or, rather, downstream, relies either on a unified system of real-world data or on a system in which product and processes are made representative.
In the absence of real world unified information at the downstream level, any technology-neutral way of assessing whole-life carbon must rely on relatively fixed and rigid upstream categories. These need to be defined and measured. Policies that rely on these definitions and measurements help to generate such knowledge and make it public.

Ecoinvent’s practice of combining and cross-referencing different data sources shows the importance of reframing and evaluating policy mixes from a pragmatic perspective, that is, from the perspective of the LCA practitioner. Only by taking the perspective of practitioners, we can adequately evaluate the contribution of different voluntary initiatives or public policies to their capacity for producing LCIs that are regarded as sufficiently reliable (or not) for basing policy on them.

There are potentially cumulative and conjunctive effects of information disclosure, as there are two mechanisms at play: First, cross-referencing between different data sources enables LCA practitioners to come up with more reliable estimates of products’ environmental impacts. This can have a conjunctive effect, where the effects of the availability of one data source cannot be seen in isolation from its combined use with other data sources.

Second, there are potentially cumulative effects, as a limited amount of data can enable the producers of LCIs to make ‘conservative’ estimates, which may then help to elicit information disclosure from industry. In this way, there may be a complex dependence of data sources, seemingly independent from production-based monitoring and reporting, on the prior availability of data stemming from the latter, as the ability to produce plausible conservative estimates may help to elicit more data from producers directly. Due to the presence of cumulative effects, where state intervention manages to elicit detailed information from industry it may have indirect leverage effects, by helping to provide credible ‘conservative’ estimates, which can then be used by LCI compilers, eventually triggering further disclosure by industry.

The budgets of LCA database providers are very low, considering their importance for the LCA community. Where the budget is limited, the production of reliable and open data on industry performance, as achieved by the IPPC process, would have been difficult to pull off by the LCA database suppliers themselves. Also, government support has been important in helping the emergence of GaBi and Ecoinvent, both in terms of direct funding, in the case of

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32Interview with Mark Goedkoop in August 2017.
the Swiss Ecoinvent, and indirect funding, via the German academic system, in the case of Thinkstep. Governments support LCA databases via various routes: they fund LCI database providers, procure datasets themselves and support institutional arrangements that provide incentives for third-parties to procure LCI databases. This chapter shows that they also, indirectly, provide them with data via the informational side-effects of their policies.

My findings here go in line with Dingwerth and Eichinger’s (2014, 243) conclusion that “commercial intermediaries make the information contained in GRI reports more valuable, comprehensible, and comparable to information users [thereby creating] conditions under which information becomes ‘actionable’”. In fact, this conclusion can be expanded to a range of different initiatives, as long as they supply LCA database providers with the required information. However, the analogy between what Dingwerth and Eichinger examine and the case of EPDs is only partial: their investigation remains at the level of company disclosure and evaluations. In contrast, here I consider the fact that GRI and similar initiatives can provide informational raw material to LCA analysts (see Table 11.1).

The utility of firm level environmental data in helping to inform product LCAs needs to be taken into account for a contextualisation of Dingwerth and Eichinger’s claim that the transparency facilitated by the intermediaries “empowers only ... the intermediaries themselves and the users of their services” (ibid.). In the case of EPDs the empowerment goes beyond the users of LCI databases: governments may decide to draw upon EPDs, not just in their own procurement decisions but also in terms of other regulatory incentives such as carbon taxes or whole-life carbon standards. Hence, governments – and the social movements pressuring them to act on climate change – would also be empowered by ‘actionable’ information.

Pondering the viability of tackling GHG emissions by relying on regulation, rather than on market-based policies such as cap-and-trade or taxation, Nordhaus (2013, 272) points out that “governments do not have sufficient information to write regulations for the entire economy”. Furthermore, it would be “impossible to design regulations for every sector, energy good, and service”. While I do not seek to argue with Nordhaus’ position at its core, in order to clarify the relevancy of my findings for the climate change policy debate, it makes sense to put the first quote by Nordhaus on its head: we can observe that performance-based government regulation has substantially contributed, directly and indirectly, to
the availability of data on the environmental impacts associated with the production of goods and services. The availability of such data would allow it to craft policy for different sectors in far more general terms, in terms of life cycle carbon emissions, than it would be the case if one had to rely on mandating specific technologies downstream. If such sector-specific policies would indeed still be necessary at a later stage is questionable, as the availability of information on embodied emissions may help to enable the cross-border levelling of carbon prices, and thus perhaps enabling the decarbonisation of sectors solely via a carbon price.

From an informational perspective, the fact that a carbon price allows for an economising of the information needed by a regulator can also have the effect that information on the emissions intensity of specific technologies, processes and products is not obtained by the regulator, as it is not needed for the regulation to occur. This, in turn, will either maintain informational asymmetries, or even fail to provide an incentive to companies or trade associations for obtaining more sophisticated measures of how carbon emissions are associated with specific products and processes. An example for this is the apparent decrease in relevance of establishing BATs with regard to carbon emissions, as major emitters are supposed to be regulated by the EU ETS. Here, the benchmarking that forms the basis for free allocation still provides some information on BATs, albeit indirectly.

The benchmarking under the EU ETS is a response to the problem of carbon leakage. By helping to provide information for PCFs, the data generated by benchmarking may indirectly help to overcome the problem of carbon leakage. Yet, if the problem of carbon leakage were to be overcome, thanks to the availability of PCFs, the stability of any such regime would depend on the continuation of credible measurements.

Altogether, this dependency of one informational institution upon another, conditioned upon processes of successive layering, points to the importance of being aware of the role of sequencing in information- and knowledge intensive policy fields. In order to provide fertile grounds for more ‘optimal’ policies, we may have to go through successive stages of less optimal, or elegant, policies. Although a toddler’s first steps are clumsy, this is how it learns to walk.

Combining the insights from this Chapter with those of Chapter 8 and Chapter 9 results in the chain of propositions in Figure 11.3, which makes clear that the catalytic effect of any one measure needs to be gauged in conjunction with those
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of other measures.

![Diagram](image)

Figure 11.3.: Combining propositions on LCA databases with those on firm and sectoral level data

### 11.11. Conclusion

Policies and voluntary initiatives that stipulate environmental monitoring and reporting provide important data sources for LCI compilers. The significance of these data sources for the overall availability of data sources needs to be assessed in a way that does justice to the potential conjunctive and cumulative effects, i.e. the possibility that in themselves unreliable data may still be used for triangulation purposes and that rough, ‘conservative’ estimates can be used to elicit more data from companies.
11.11. Conclusion

The key difference between this chapter and those on the developments leading to greater availability of data at the firm and the sectoral level is based on that between primary and secondary data. This chapter suggests that the availability of quality secondary data may motivate producers to provide more primary data.

Policies that require a lot of information help to generate an informational surplus upon which LCI compilers can draw. In contrast, policies that actually managed to successfully ‘economise’ on information would not generate such a surplus. If more and more environmental policies managed to do with little information there would be less public data sources available to LCI compilers.

Pure pricing schemes that managed to do away with the need to generate emissions factors would equally fail to generate the informational surplus that has stimulated the expansion of knowledge on the environmental impacts embodied in products. The absence of such product level information would pose a barrier to the ambition level of any pure pricing scheme, as it would run against the problem of emissions leakage.

The very inability of pricing schemes to radically economise on information requirements results in the need for benchmarking. Benchmarking contributes to the data needed for the inclusion of consumption into pricing schemes. Once consumption is included into carbon pricing schemes, carbon pricing’s potential for technology- and material neutrality may eventually realise. For this potential to realise, however, a lot of information would be needed.
12. Discussion

This section spells out the joint implications of the empirical chapters and relates these to the overarching theme on how to work towards more effective polycentric governance of the atmosphere. I show how multiple processes of rescaling and rescopying – in terms of information, policy and politics – have been interacting and thus offer an empirically grounded yet holistic treatment of the evolution of transnational climate governance, which also offers a plausible glimpse into future possibilities and which can thus guide action.

I discuss the results of the empirical chapters along two thematic strands. Section 12.1 reflects on the informational interactions across the diverse polycentrically distributed policies and initiatives that have helped to create and elicit the information that has allowed to make the carbon emissions associated with products and services to become ever more commensurable. Section 12.2 discusses what can be learned from the empirical chapters with regard to how prior policies and initiatives have affected the informational conditions for the political mobilisation of actors in favour of embodied emissions policies. It also argues that embodied emissions policies correspond to a more pluralist structure of interest representation than policies targeting upstream emissions. In addition, the section speculates on spillover effects between the instrument constituencies of the embodied emissions network and those of corporate carbon accounting and carbon markets. It concludes with a cautious note on the tensions between the productive development of a new constituency demanding the establishment of embodied emissions policies, driven by the motivation to secure competitive advantage, and the need to make sure that the untrammeled pursuit of such interests does not undermine prospects for global cooperation on climate change.

The real-world significance of the empirical results can only be appreciated once we acknowledge the potential of using the informational infrastructures that enable such carbon commensurability as the backbone of polycentric governance practices in the form of monitoring and sanctioning activities amongst the users
of the atmosphere. Accordingly, Section 12.3 reflects on the role of embodied emissions policies within the context of a global polycentric governance structure. The chapter concludes with sections on the significance of the findings and their policy, the limitations of the study, opportunities for further research, and an outlook.

12.1. Informational interactions across policies and voluntary initiatives

This study has shone a light on multiple interactions across public policies and voluntary initiatives. My analysis has focused on the layered use of information, elicited by one institution and then drawn upon by another, and its relation to the sequencing of different institutional developments. Doing so has contextualised the informational contributions of different policies and initiatives within the overall framing of polycentric governance processes which may eventually enable the mutual monitoring and sanctioning of the atmosphere’s ‘users’.

The adoption of an informational-institutionalist perspective on climate governance and policy leads to a radical re-evaluation of existing approaches and policies (on informational institutions see Section 3.2). From this perspective, I arrived at novel assessments, disagreeing with or complementing those of other authors regarding the joint implications of a range of policies:

- energy efficiency standards,
- carbon pricing,
- environmental technology standards,
- corporate environmental disclosure, and
- product carbon footprints.

In the following I will first discuss how this perspective reveals the informational and institutional contributions of existing, polycentrically distributed policies and initiatives to a fuller extent than hitherto appreciated. It enables us to better appreciate that policies and initiatives that may lack effectiveness by themselves can still act as the foundations of potentially more effective policies. Even more so if one takes into account the potential of consumption-based
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policies to provide sanctioning mechanisms that may help to move the climate
change governance landscape closer to an institutional set-up comprising core
elements of what Ostrom has identified as conducive to the establishment of
common property regimes.

Adopting a sequential approach to policy analysis, as I have done here, allows
to re-appreciate the role of regulation. Regulation is sometimes presented only
as a second-best approach. For example, for Stern (2015, 111):

“Regulation can be an effective alternative when political constraints
preclude the adoption of market-based schemes.”

Here, Stern presents regulation solely as an alternative to market-based
schemes. However, I have shown how regulation can, over time, help to work
towards making market-based schemes more technically, institutionally and
politically feasible. Regulation can therefore be an enabler of market-based
schemes.

Energy efficiency policy stimulates the creation of knowledge on energy con-
sumption, which helps to improve the capacity for making embodied and use
phase emissions in product standards commensurable, helping to make the case
that product level disclosure could actually help assessments of buildings’ over-
all carbon efficiency. While a relentless focus on energy efficiency may indeed
run the danger of the saved emissions being partially or wholly offset by in-
creased consumption (the rebound effect), and at some point the saved energy
consumption may also be offset by the emissions embodied in the building ma-
terials (Sorrell 2007, 2009b; Ayres and Warr 2009), the energy efficiency agenda
has managed to create a body of knowledge and the expertise of practitioners
about energy efficiency in buildings, which cognitively supports commensuration
processes between energy efficiency and embodied emissions.1 Ultimately, this
also rests on advances in the energy efficiency of buildings, which have helped
the question of embodied emissions to more prominence (see Chapter 6). Cer-
tainly, from an economic efficiency point of view it may have been preferable to
directly steer energy efficiency investments via a carbon price rather than via

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1As Marszal et al. (2011) suggest: “The need for a robust [Zero Energy Building (ZEB)]
calculation methodology has gained attention with the growing number of ZEB projects
and thus the interest in how the ‘zero’ balance is computed.” Without a solid methodology
to calculate a building’s net energy consumption, an even more sophisticated assessment
of a building’s holistic carbon footprints, which would at least take both operational and
embodied emissions into account, is not feasible.
direct regulation. However, on the one hand, the ability of such an instrument to generate political support is much more limited, as Yandle and Buck (2002, 193) and Meckling et al. (2015, 1170) rightly point out (although I do argue for the need to complement their view with some specifications). On the other hand, without the establishment of institutions that make the carbon emissions embodied in products transparent, it is difficult to act against carbon leakage in a principled manner, thus running the danger of either undermining the ambition for effective carbon pricing, or of triggering trade wars.

A contribution of the present study concerns the relation between the enabling of consumption-based approaches and carbon pricing in the sense that prior analyses of the political and environmental fruitlessness of carbon pricing have or have not acknowledged the problems of carbon leakage but have not connected other policies in the sense of acknowledging their potential to contribute towards the informational requirements of addressing carbon leakage. If monitoring requirements, either as stand-alone or as part of policies aimed at reducing emissions, help to improve the basis for policies that take embodied emissions into account, one needs to evaluate the merits of those policies or initiatives that induce the monitoring with respect to these indirect effects. Such monitoring requirements have arisen both from carbon pricing and energy efficiency policies (see Chapter 8, Chapter 9, Chapter 10, and Chapter 11). By analysing multiple policies together, within a timeframe of two decades, I show how one policy prepares the information on which another policy can then draw. I show how this perspective of informational institutionalism (see Section 3.2) can be fruitfully applied to the study of processes of carbon commensuration (see Section 3.3), and how such commensuration processes have the potential to contribute towards tackling the problem of embodied emissions.

Drawing lessons from the history of British carbon policy, Helm (2010, 195) concludes that “market-based instruments are generally to be preferred to picking technologies; and taxes are generally better than permits.” However, if one applies an informational perspective and looks at which measures have actually managed to elicit information from industry, one can see that the IPPC, geared towards finding BATs, has been quite successful, at least insofar as it has helped to contribute towards the improvement of emission factors and LCI databases.

For LCA, some of the most important ‘carbon policies’ have consisted in the

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2Of course, not everybody argues for the innate superiority of market-based instruments (Ekins 2010; Jänicke and Lindemann 2010).
elaboration of BATs and emissions factors (see Table 11.1 in Chapter 11). Data provided by the IPPC process and EPA’s BAT-finding exercises has helped to equip LCA database providers, particularly clearly in the case of Ecoinvent, with plausible data to use as a basis for coming up with conservative estimates, which provide industry with an incentive to provide more data, in order to show that they perform better than what conservative estimates suggest (see Chapter 11). Now, one could argue that any estimate may suffice that makes an industry look bad; however, it seems important that such conservative estimates are still plausible in order not to undermine the epistemic authority of LCA database compilers.

The importance of the role of generic data in the field of EPDs, whose existence helps to stimulate the provision of specific EPDs, has an analogy to Grubb’s idea to offer reduced import tariffs to those importers who can prove that their products outperform carbon benchmarks (see Chapter 2). Interestingly, Grubb et al. (2014, 294) also suggest drawing on BATs – exactly the same informational resource on which LCA database providers have drawn quite considerably.

It is difficult to imagine a tax, at least where it lacks any kind of alleviation mechanisms targeted at preventing carbon leakage, and thus lacking benchmarking exercises, delivering similar informational benefits as a BAT-finding exercise. Certainly, a tax, in itself, if it could be made to work in a sufficient number of countries at a sufficiently high price, would be more desirable than the extremely complex efforts of life cycle carbon assessment. However, under far from perfect circumstances, an overly complex solution is preferable over one that does not seem attainable; even more so as the introduction of policies designed to limit the consumption of emissions embodied in goods could help to exert the necessary leverage to convince trade partners to also introduce more stringent carbon policies (and perhaps join a ‘carbon club’ (Keohane and Victor 2016, 573)).

Climate economists have long advocated for carbon pricing as a more efficient policy over technology-specific standards, partly as the government thus refrains from rigidly prescribing specific technologies and thus leaves optimising behaviour to those actors who are closest to the matter to be addressed, which may help to stimulate learning. However, there is reason for doubt that market-based mechanisms can actually do with little information. One needs to come up with suitable emissions factors, or continuous monitoring equipment needs to be calibrated and checked (McAllister 2010). In case of emissions trading, IT
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systems need to be guarded against fraud. An international linking of carbon pricing systems would increase the challenges of monitoring and verification of emissions (Flachsland, Marschinski, and Edenhofer 2009).

In addition, if direct measurements were completely possible, there would be no need for emission factors. If there was no need for emissions factors and they would not be produced, they would also not be available for the LCA community, thereby drastically diminishing the amount of publicly available data for modelling the GHG emissions embodied in products. It is the informational requirements of emissions monitoring, which subsequently would extend to any attempt at regulating the emissions themselves via price signals or permit trading, which lead to the provision of information on the emissions associated with specific products to the LCA community.

Some of the emissions factors have been perfected by another important public source of LCA data, which has also resulted in its own repository of data: governmental standard-setting activity, which involved the identification of available technologies in the industry population, such as conducted under the European IPPC and IED Directives and by the US EPA. Such initiatives do not at all economise on information, on the contrary: their rationale is based on gathering a lot of information and then debating it in fora comprising multiple stakeholders. From an economic point, such arrangements may be highly inefficient and, from a public choice perspective, they may be prone to regulatory capture. Yet, they do provide a lot of publicly available, relatively representative and vetted information, which can be used by the LCA community.

Ironically, it is those policies that are less purely market-based, such as command and control policies, energy efficiency mandates and free allocation of emission permits based on benchmarking, which, due to their very data requirements, also contribute more to carbon commensurability at the epistemic level (rather than in market terms). By increasing epistemic carbon commensurability, they can help to enable more technology-neutral consumption-based carbon policy.

Economists, who favour market-based instruments over direct policies such as technological and performance standards (Goulder and Parry 2008, 157; Helm 2010, 193; Nordhaus 2013, 272), may find it instructive to follow the informa-

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3As explained by Jos Delbeke, Director General, DG Clima, European Commission, at the INOGOV Workshop The Global Turn to Greenhouse Gas Emissions Trading: Experiments, Innovation, Actors, Drivers and Consequences in February 2016.
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ational side-effects of policies, which I described in the empirical chapters. When considering the informational effects of policies they may find that by taking into account the sequencing of policies and the building up of interlocking informational institutions, gradually, less ‘optimal’ policies can form bridges that increase the feasibility of their preferred policies. It may be the case that only imperfection leads to perfection.

The informational disadvantage of government would presumably not play a role anymore if market-based instruments were adopted. Yet, the government would then also fail to generate information. This information would then not be available at the level of consumption-based approaches. Where the lack of information inhibits the functioning of consumption-based approaches, the potential of market-based instruments for “optimally engag[ing] the various channels for emissions reductions” (Goulder and Parry 2008, 157) would then remain limited.

To summarise: less than perfect technology-specific policies at the level of emissions sources can enable more technology-neutral policies at the level of the life cycle carbon emissions. The ‘friction’ caused by problems in the way of directly pricing emissions without any further adjustments helps to rescope information on carbon emissions from the locus of production to the product, from point to flow.

This thesis also also contributes to the debate on the merits of voluntary transparency initiatives. Based on an extensive sample of environmental disclosure initiatives, Mason and Gupta (2014b, 336) find support for their hypothesis that “transparency has minimal market-restricting effects”. If however, it should eventually turn out that the EPD regime, which, at least partially and indirectly, benefits from some of the initiatives considered by Mason and Gupta (2014a, 27) – such as CDP, GRI and FSC4 – forces market actors to substantially reduce carbon emissions, for example based on public procurement, as envisaged in California, or via building standards, as advocated for by sustainable building actors in the UK and Germany, then the support for their hypothesis would crumble. In particular if one does not solely focus on acts of voluntary disclosure themselves but also on how LCA database providers appropriate such data.

CDP and GRI probably benefit from companies being subjected to environ-

4The eagerness of the NRCMA to engage with EPDs can be explained by their desire to make concrete products entitled to obtain points under LEED, which FSC certified wood products had been able to obtain already (see Appendix, Section A.6.5). Ultimately, EPDs and FSC certification can be drawn upon in commensuration processes geared towards assessing whole-life carbon emissions.
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Voluntary disclosure under CDP and GRI could be – at least partly – seen as merely another outlet for data generated in response to government requirements for monitoring and reporting. Where this is the case, the critique that “transparency has minimal market-restricting effects” may be less relevant, as transparency would be an epiphenomenal development, with government regulation being a more important driver. However, where transparency leads to additional measurements, which may then benefit the availability of product level data (see Chapter 8, Chapter 9, and Chapter 11), it may indirectly aid more market restricting policies.

Chapter 11, Section 11.8, shows that corporate environmental reporting à la GRI can help to provide some data for LCA database providers. Chapter 9, Section 9.4, suggests that the EU Directive on corporate reporting, which explicitly allows for GRI to be an option, has also led to more employment opportunities for experts on environmental reporting. Section 9.5 provides evidence that some of these are likely to also have knowledge of LCA, thus indirectly helping to improve capacity for product level disclosure. The EU has layered onto voluntary frameworks such as the GRI, or – to use a related concept – engaged in a form of cross-over scaling where they permitted a non-state intervention to affect conventional public policy. As a consequence, disclosure initiatives, which may exert “minimal market-restricting effects” by themselves (A. Gupta and Mason 2014b, 336), become the vehicle for improving organisational capacity in such a way that the introduction of policies which restrict the circulation of carbon intensive goods becomes more feasible.

Where a danger of environmental disclosure is that the consumers of the released information may ‘drown’ in a plenitude of difficult to digest and potentially untrustworthy information (Mol 2014, 48; Gupta and Mason 2016, 87), and the information is marked by a lack of commensurability (see Section sec. 2.6), I argue that intermediary standards and organisations can help to distil information into formats that are more digestible and actionable: EPDs and PCFs. From the perspective of the LCA practitioner, far from ‘drowning’ in data, such a plenitude of information offers opportunities for triangulation (see Section 11.8).

Ormond and Goodman (2015, 129) suggest that PCFs would solely concern
12.1. Informational interactions across policies and voluntary initiatives

the private governance of consumer behaviour or supply chains, which runs the
danger of “sidestepping a more confrontational engagement with the unsustain-
able consumption practices at the heart of climate change” (see also Section
2.6). Yet, if one accepts the argument presented here – that product carbon
footprinting is a potentially crucial building block for also addressing consump-
tion in carbon policies, and thus an enabler of higher carbon reduction ambition
levels – these critics would be challenged to reformulate or qualify their argu-
ments.

Vogel (2005, 173) insists that “‘soft’ civil and ‘hard’ government regulation
can and should be reinforcing”. I show how a new generation of eco-labelling
programmes has the potential to strengthen mandatory environmental regula-
tion, both nationally and internationally, and that there is indeed a strong
re-enforcement of civil and government regulation. While I concede some of the
criticism levied against environmental disclosure and management, I argue that
we can observe successive processes where actors have drawn on the information
elicited or created by others, and on the standards others have drawn up, to
bring about forms of accounting for carbon, and environmental impacts more
generally, that are, at least potentially, more relevant for policy-making and the
mobilisation of actors around advocacy for political reform, than the critics of
environmental management and disclosure initiatives have so far acknowledged.

The identification of eco-labelling with the domain of private governance is
rather misleading. While private actors are in the limelight of the emerging
EPD complex, public actors have helped to enable this emergence all along.
From the requirements for companies to record their environmental emissions
over making data on environmental performance publicly available so that LCA
database providers could draw on this data, to funding LCA database providers
themselves or supporting related research via academic institutions5, to request-
ing the setting of standards for EPDs and using public procurement in order to
create demand for green building schemes and, as a consequence, EPDs, it has
always been one or the other government pushing forward the EPD train.

Knowledge on the underlying institutional configurations that make one mode
of institutional change more likely to occur than another one helps us to explain
when which mode of scaling is more likely to occur, simple or synergetic scaling –

5Both the EcoInvent as well as the GaBi database emerged thanks to public funding. EcoIn-
vent has received money from the Swiss government while GaBi is a university spin-off (see
Chapter 11). Their private authority thus arose on the back of state support.
12. Discussion

whether an existing institution or organisation takes on new functions or whether these are developed by another one. Thus, the co-evolution of private and public actors (Bleischwitz, Andersen, and Latsch 2005, 170) can be explained in more detail. In the case of EPDs and LCA, one can see a great number of institutional differentiation, with different organisations working synergistically together. If government tried to develop LCA databases, green building certifications and EPD schemes all by themselves, there might be more problems from veto players opposing the general direction or specific design features, either from within government or from industry. Similarly, if a government developed all these functions, it may find other governments vetoing certain features, making it more difficult to upscale any initiative beyond one country. The presence of veto players makes drift and layering more viable modes of institutional change. By relying on and supporting private transnational regulatory activity, governments can effectively support a field while still keeping its protagonists, as these are supposedly independent, well shielded from veto players.

The private organisation of product labelling and the private promotion of these labels by meta-labels in the form of green building schemes, chimes well with a polycentric form of governance and also benefits from avoiding the impression that some states wish to dominate others by imposing their own rules. Jordan et al. (2015, 978) note that transnational initiatives seem to be particularly apt at providing the governing functions of capacity building and information sharing. Here they may enter a mutually beneficial division of labour with states, which are more constrained by operating at a restricted spatial scale.

Rescaling across issue areas has been an important factor, as can be seen in sustainable building councils and standards, which deal with sustainability issues more generally but also with carbon emissions specifically, and PCFs often being packaged as part and parcel of EPDs. Anybody who looks at climate governance, be it from a more economic or political perspective, should pay heed that the informational requirements of consumption-based approaches may not be limited to carbon alone. Where the diffusion of information on embodied emissions depends – if only at a certain stage – on private standards and voluntary disclosure by companies, information on embodied emissions may only come as part of a package including the general availability of information on the environmentally relevant flows associated with the production of goods. Any narrow perspective on PCFs risks ignoring how they emerge as part and parcel of wider LCA information. A fruitful analysis of climate policy must thus take
12.1. Informational interactions across policies and voluntary initiatives

the wider environmental policy landscape into account.

As it stands, the bottom-up development of consumption-based climate policy is intricately intertwined with the development of the wider LCA field. For a while, the singling out of carbon footprints, in isolation from wider environmental impacts, seemed to signify a ‘going alone’ of the carbon agenda (see Section 7.1 on the PEF). However, such an approach is vulnerable to the criticism of shifting problems merely from one environmental impact to another, or that of being reductionist. For the assessment of whole-life carbon emissions, it may suffice to solely have a functioning carbon footprint. Ultimately, however, such a ‘carbon only’ approach may undermine the legitimacy of consumption-based policies.

Corporatist arrangements, in the sense of Falkner’s conceptualisation (see Section 3.4), are well-suited for endowing trade association with the function of mediating information flows between companies and the government. This function can then be drawn upon for the issuances of sector-specific EPDs. In this way, corporatist arrangements can be a facilitator of EPD production, as they lower transaction costs (see Chapter 8).

The ETS systems are examples of both corporatist arrangements (in the sense of Section 3.4) and mere efficiency-increasing policy mechanisms, with the potential to stifle transformative innovation processes, as they fail to transmit price signals in a truly material and technology-neutral way. Corporatist systems may also make it easier for companies to put up a common front against government, thus making it easier to preserve information asymmetries. Yet, due to their facilitation of EPD production, the same corporatist arrangements can also help to shift the policy focus from production to consumption-based measures, or, from another perspective, to production activities further downstream.

Where corporatist situations help to produce sectoral life cycle data sets, however, these may be used to obtain information that allows to compare products from different sectors and draw up relatively material and technology-neutral downstream standards that include embodied emissions as a criterion, thereby enabling policies which are not specific to any one upstream sector. This may then lead to a more pluralistic action situation during the political process and stakeholder deliberations on such policies. Accordingly, a corporatist situation may beget a pluralist one.

Relating this back to the conceptual apparatus of common-pool resource governance scholarship in the Ostromian fashion, government responsibilisation or
other pressures that leads companies to share data within trade associations can help to stimulate learning and build mutual trust, which then facilitates further data sharing for the purpose of assessing embodied emissions at the product level. This can be interpreted as another instance of polycentrically distributed feedback effects. If the government ordered directly to individual companies to produce PCFs or EPDs in a concentric manner, we could imagine a more direct establishment of the preconditions for a pluralist competition based on whole-life-cycle carbon standards for products. In contrast, the pressures to which companies of the same sectors are subjected to lead them to cluster together, i.e. to form multiple centers of collective monitoring and information exchange. We can therefore observe a polycentric pattern.

12.2. Political mobilisation

Finding a general rule that can unite otherwise divergent interests can be the key to making a policy politically feasible. Where the information on the carbon emissions associated with products becomes available, at a higher level, downstream in the value chain, policies can be employed, which favour certain products over others in a way which is in accordance with general principles and not with the picking of specific products. In doing so, the support of heterogeneous sets of producers can be gained, which can all unite behind the banner of a general policy, which still promises to, jointly, reward their specific products. As such, the rescoping of climate policies tends to be accompanied by a re-aggregation of interest groups in climate politics.

A contribution of the present study relates to the mobilising power of carbon regulation. Yandle and Buck (2002, 193) and, later, Meckling et al. (2015, 1170) suggest that carbon pricing may in itself not be a fertile instrument for fostering a strong coalition of businesses that support a ratcheting up of the carbon price. Yet, by only looking at how ‘policy makes politics’ in a rather immediate way, one overlooks the indirect and unintended catalytic effects carbon pricing initiatives can have at later times and at other levels. With the privilege of hindsight, I argue that their assessment is in need of a complementary perspective, offering a fuller view. First, Chapter 8 and Chapter 9 argue that actual carbon pricing, or the anticipation thereof, has historically catalysed the better availability of information and capacities for the product-level disclosure of carbon footprints in the form of EPDs at the levels of sectoral associations (Chapter 8), as well as
12.2. Political mobilisation

those of firms, and consultants (Chapter 9). While some of that data could have been obtained by GHG emissions standards instead, a pure focus on the other two major pillars of climate mitigation policy, energy efficiency and renewable energy, would not have been sufficient to generate that kind of data. Thus, the targeting of carbon emissions at the source has helped to increase the availability of information on the emissions embodied in products. Even an ineffective, low carbon price may provide substantial benefits down the lines, as it stimulates the production of information and expertise on carbon emissions and thus facilitates carbon commensurability (on commensurability see Section 3.3).

The prior implementation of carbon pricing in California was an important argument for the Buy Clean California campaign. While that campaign has not advocated a ratcheting up of the carbon price, they did successfully advance public procurement requirements aimed at tackling carbon leakage. And carbon leakage is an important stumbling block on the road towards more effective carbon pricing (see Chapter 2). In that sense, this coalition may not have directly supported a higher carbon price, but they have contributed towards making a ratcheting up of the carbon price more economically viable for Californian producers. That chapter also shows how carbon disclosure at the product level supports a new common framing for a coalition demanding a greater role of embodied emissions in the building sector.

Carbon pricing, or its anticipation, is also likely to have provided incentives for adopting energy efficiency measures, which may have helped to improve the availability of high quality data for PCFs (see Chapter 10).

The privilege of hindsight permits to go beyond Yandle and Buck (2002) as well as Meckling et al. (2015) in arguing that carbon pricing policies have catalysed a variety of slowly unfolding developments, here in particularly in the domains of carbon information, informational institution-building, and carbon efficiency, that eventually jointly produced the conditions for the Buy Clean California coalition to successfully argue that Californian producers’ carbon efficiency was relatively higher than those of their competitors, and that the informational and institutional requirements for taking this into account in procurement decisions were ripe, too. Here, the initial adoption of carbon pricing had feed-forward effects, which improved the conditions for acting against carbon leakage, which then might potentially feed back to the conditions for the continuation or change of already established carbon pricing policies.

Complementary to this, there is good reason to assume that actual carbon
12. Discussion

pricing, or the credible threat thereof, has helped investors to pressure companies to disclose climate risks, and that this has contributed to a greater level of environmental reporting overall (see Section 9.4), and indirectly created better capacities in firms to create LCAs (see Section 9.5). Where this helps to diffuse EPDs and make new consumption-based measures available, one can observe a rescoping of climate policy, from targeting production to products, and – correspondingly – a re-aggregation of interest group identities in climate politics (see Chapter 5). The argument that carbon pricing does not have a mobilising effect for business thus loses some of its empirical support. Its effect may not be direct but in slow, complex and diffuse ways it has enabled a new actor constellation with a new political dynamic. In addition to this, the low level of carbon pricing and the difficulty in ratcheting it up is also partially due to the problems standing in the way of an effective levelling of carbon prices at the border. This limits the extent to which one can base claims of the political sterility of carbon pricing on empirical evidence, insofar as a potential situation where carbon leakage is remedied cannot be empirically analysed. Also, once one allows for the possibility that embodied emissions information may be drawn upon for product-based policies, some of the policy constituency mobilising features highlighted by Vogel (1997, 560) and Yandle and Buck (2002, 193, 210, 217) may come to manifest, too.

At least the case of the CSI and their EPD tools has shown that the building up of informational institutions in the face of potential ‘carbon policy’ has contributed to making policies targeted at embodied emissions more feasible, which could bolster possibilities for eventually ratcheting up carbon prices.

When looking at the institutional factors conducive to the rise of EPDs, we have to re-asses prior judgements alleging the political sterility of carbon regulation (J. Meckling et al. 2015) and the rejection of firm-based disclosure initiatives as solely symbolic exercises (Wright and Nyberg 2015). Anticipated or actual regulation and firm-based disclosure initiatives have been conducive to the availability of information for EPDs, and the availability of EPDs has made policies feasible, that have the potential to lead to a re-aggregation of interest groups. Therefore regulatory activity and firm-based disclosure initiatives at

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\(^6^\)There are other framings that assert a common group identity such as the Energy Intensive companies (see e.g. Energy Intensive Users Group 2018). However, in contrast to the embodied emissions coalition, this framing is defensive in nature, and also rests much less on the construction of a sophisticated knowledge apparatus than the embodied carbon framing.
12.2. Political mobilisation

time $t$ may help to improve the conditions for the mobilisation of pro-regulatory coalitions, hitherto less plausible, at time $t+1$.

I have shown that the requirements for monitoring and reporting, which are a corollary of any pricing approach, can be conducive to the diffusion of EPDs, as they can increase the information availability at firm or sector level, which may eventually be drawn upon during the creation of EPDs (see Chapter 8 and Chapter 9).

Certain policy approaches, such as the free allocation of emission permits based on benchmarks, finding of BATs under the IPPC regime, as well as climate agreements between industrial sectors and governments promote a corporatist structure of negotiation between government and industry. In contrast, when it comes to downstream negotiations over standards, the situation is more pluralist. The life cycle benchmarking of buildings promises to put different building materials producers into competition for the lowest carbon footprint. Re-scoping of policies based on place-based to placeless disclosure is thus likely to affect which structure of representation is dominant. Where the ‘mission’ of policy is not to lower a sector’s carbon emissions but to decarbonise the entire economy, more pluralist arrangements, which retain a possibility for inter-sectoral substitution in accordance with materials’ carbon profiles, seem more promising.

Another important aspect is the way downstream standards for final consumer products like buildings or automobiles should empower downstream producers and service providers to participate in deliberations on the details of policy design. This is in contrast to pricing schemes that target upstream products. As there are different materials and designs for the construction of buildings and vehicles, such deliberations could draw a more heterogeneous group of stakeholders than deliberations on the upstream benchmarking of emissions and the allocation of permits. Such a greater pluralism in debates on how to improve the carbon efficiency of products is likely to generate a greater variety of useful ideas for radically decarbonising physical infrastructures rather than sectorally limited attempts to decarbonise specific products. In a seemingly paradoxical way, many of the informational foundations for such a greater pluralism were borne out of informational exchanges focused on specific upstream sectors, which may be regarded as rather corporatist arrangements.

LCA information on products enables new, non-price competition principles, for which diverse stakeholders can jointly lobby for rather than for material specific privileges. Such material-neutral policies are in tune with neoliberal
principles of creating the conditions for competitive markets, which can be used as a ‘discovery procedure’ (Hayek 1990, 179ff.) or the revelation of ‘a truth’ (Foucault 2008, 32).

For Newell and Paterson (2010, 104) the EU ETS has succeeded in endowing “city traders, project developers for offset projects, the management consultants helping companies engage in ‘carbon asset management’, the auditors assessing the emissions of companies and so on [with] a vested interest in progressively stronger climate policy”. In effect this means that an institutional field was established, which could potentially further expand, partially driven by its own interest in doing so. This could also be reframed in terms of an ‘instrument constituency’ (Voß and Simons 2014). Here we see strong analogies to the rise of the ‘embodied emissions’ network.

The following can be seen as some central elements of such an eco-system:

- LCA databases,
- public policy processes providing data for the LCIs in LCA databases (see Section 11),
- governments having supported the development of LCA databases,
- governments providing incentives for the production of generic data and EPDs via public procurement,
- consultants conducting LCAs for EPDs,
- EPD verifiers,
- standard-setting bodies such as ISO and CEN and the delegates participating in their standard-setting procedures,
- creators of Product Category Rules, and
- green building labels that act as a form of higher order codification, or, rather, meta-labels.

The institutional eco-system of carbon markets (Newell and Paterson 2010) shows complementarities and potential spillover effects, with partial overlaps, across the institutional eco-system of PCFs and EPDs. This might result in the eventual feedback of spillovers from the product field back to that of corporate accounting and carbon markets.
It is quite possible that the price one needs to pay for effective climate change policy to come about may be to build its success on the co-benefit of the increased economic benefits carbon-efficient companies and sectors can derive from carbon pricing and border carbon adjustments (see Jordan et al. 2015, 979, referring to Ostrom and the IPCC). On one level this may conflict with the principle of common but differentiated responsibilities, where it leads to industrialised countries’ companies to become more competitive, but this may still be cushioned by greater overall reduction targets for industrialised countries. One would need to straddle a fine balance between mobilising domestic organised business interests in favour of border carbon adjustments and other embodied emissions policies with the promise of competitive advantages and the adherence to principled measures that avoid the impression of embodied emissions policies being taken up with protectionists interests prevailing, which could run the danger of undermining global cooperation on climate change.

12.3. Embodied emissions policies within the context of a global polycentric governance structure

I argue that extant climate, energy, and wider environmental policies and initiatives have helped to enable consumption-based approaches in climate policy. Insofar as the adoption of climate policies can be attributed to the UNFCCC process, and their informational side-effects could enable consumption-based approaches which then would alter the dynamics of the UNFCCC process, we may speak of feedback effects the UNFCCC process could plausibly exert onto itself.

To the extent that carbon pricing and those energy efficiency policies justified with reference to global warming mitigation efforts are consequences of the emission reduction obligations nation states have taken up within the UNFCCC, one can observe that these policies have helped to improve the technical feasibility of consumption-based accounting and policy measures. They have therefore contributed to preparing the ground for two potential feedback effects towards the level of the UNFCCC: first, they have helped to prepare the ground for the adoption of consumption-based accounting at the micro-level. Second, where it enables border carbon adjustments, the ambition level of countries regarding production-based emissions may be improved.

We could conceptualise this feedback loop as starting with the UNFCCC, then exerting its informational effects via a range of polycentrically organised
policies and initiatives, which then enable the adoption of new policies in equally polycentric manner, which may then eventually feed back onto the UNFCCC.\footnote{While this image of a centre, which exerts polycentric feedback effects onto itself, does have some aesthetic attraction, it may be misleading to translate the formal central positioning of the UNFCCC into an ontological centrality. Instead, the UNFCCC might be regarded as a special, central forum situated within a structure that has always been characteristically polycentric.}

For all the positive aspects of BCAs, putting up trade barriers against developing countries, who are often less carbon efficient, also has equity implications. As developing countries’ production is often less carbon efficient, the introduction of BCAs by industrialised countries would change the terms-of-trade against developing countries (Sakai and Barrett 2016, 108). Consequently, developing countries tend to oppose BCAs as a form of protectionisms against less industrialised countries (Sakai and Barrett 2016, 103f.). In particular, developing countries have insisted that BCAs conflict with the UNFCCC’s principle of ‘common but differentiated responsibilities’. According to that view developing countries should shoulder less onerous abatement burdens than industrialised countries and therefore not have to suffer from the disadvantages arising from BCAs (Sakai and Barrett 2016, 104).

However, if BCAs serve to abandon the free allocation of allowances in industrialised countries, the equity concerns would be less grave. In addition, Sakai and Barrett (2016, 108) argue that the equity concerns against BCAs could be minimised by earmarking the revenue from BCAs for assistance to the exporting nations. However, ideally high carbon prices and BCAs would make carbon intensive products unattractive choices for consumers. If industrialised countries ended up outcompeting developing countries on the basis of ultra low carbon technologies, technology transfers could be a way of addressing equity concerns.

One could also criticise that industrialised economies imposing BCAs and other consumption-based policies needed to implement surveillance mechanisms targeted towards developing countries’ industries. This could also be seen as an attempt to interfere in the sovereignty of rising power, such as China. These concerns make it advisable to pursue a parallel strategy of implementing measures in a unilateral way, thus further strengthening the capacity for transnational carbon accounting of products along supply chains and normalising this approach, but also deliberating in international fora at the UNFCCC to work towards wide-reaching consensus and buy-in. Ideally this should be complemented by liaison between the UNFCCC and the WTO to minimise the likelihood of a
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Border carbon adjustments and embodied carbon standards are politically sensitive and, if badly designed or communicated, with too much emphasis on the competitive advantage that can be derived from the policy instruments, could provoke a backlash undermining international cooperation on climate change. Therefore, it is important to engage in extensive deliberation and the elaboration of clear principles in multilateral fora (see e.g. Neuhoff 2011, 200). The UNFCCC and IPCC could act as deliberative fora that help to legitimise and scrutinise unilateral or ‘club’ action, in particular where consumption-based approaches may come across as protectionist (drawing on the governance principle of analytic deliberation as described by Dietz, Ostrom, and Stern 2003, 1909). More ambitious diplomatic effort could seek to achieve a coordination between the UNFCCC and the WTO to explicitly accommodate for climate concerns and border carbon adjustments within the WTO framework and to develop standards for the assessment of the carbon content of products and services (Bachus 2018). The elaboration of such principles may draw on the work on eco-labelling that is conducted by the ISO. While such a coordination between the UNFCCC and the WTO is unlikely to succeed under current political conditions (Mehling et al. 2019, 477), it is nevertheless worthwhile to start laying the groundwork for it.

Transnational efforts to generate information on emissions embodied in products should help to enhance the quality of monitoring. Greater availability of information permits to experiment with the adoption of new policies, which themselves can help to increase the supply of information, and thereby — in a virtuous cycle — unlock new policy opportunities. Unilateral action or action by a limited ‘club’ may have a bad reputation in comparison to multilateral arrangement, which have the virtue of universality, consensus and alignment with the ‘conventional theory’ of how to successfully manage common-pool resources, but they may actually be more nimble, experimental and may also prove to be more resilient and adaptable in the face of non-cooperation by major players.

When sanctions are applied by different actors and in the form of different instruments, the governance effectiveness does not rely solely on one global institution. Without the need to wait for consensus individual countries can move forward and create incentives for other countries to go low carbon, too. The challenge would be to keep the momentum while at the same time avoid the breakdown of relations or risk a backlash. However, ultimately it is not likely
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that an entirely smooth and consensual process can be achieved and it may well
be that sanctions could be responded to with retaliations in other areas. This
makes it even more important to recur to global institution as deliberative fora
where the legitimacy of rules can be debated and specified.

It may be possible to introduce BCAs or embodied carbon standards in a less
confrontative way but more in accordance with the logic pursued under the UN-
FCCC if such action is accompanied by deliberative efforts at the UNFCCC to
take consumption more into account. This could, for instance, involve efforts to
complement production-based accounting with consumption-based accounting.

To what extent may the further diffusion of carbon labels benefit an eventual
shift towards consumption-based accounting at the level of the UNFCCC?
Consumption-based emissions are usually calculated from production-based
emissions by subtracting emissions generated for exports while adding those
generated abroad for imports. To estimate the resulting net embodied emissions
in trade data on trade flows is combined with multiregional input/output
tables (Jakob et al. 2014, 302). Whereas consumption-based accounting, as
envisaged by Peter et al. (2011, 8907) would solely rely on the system of
national accounts, a product-level certification would, in principle, allow to
 provide a higher resolution. However, its coverage would likely be more limited,
at least initially, as there would not be data available for all product groups.
Also, the availability of micro-level data in the form of carbon labels would
not immediately be useful to help improve the top-down method. However,
hybrid models, combining bottom-up and top-down data could benefit from
the availability of greater micro-level data, in particularly by allowing the
triangulating between macro and micro data (Jeswani 2017, 74).

In line with Dietz (2003, 1910) et al.'s recommendations for adaptive gov-
ernance that “[i]nstitutional arrangements must be complex, redundant, and
nested in many layers” it can make sense to nominally focus on production-based
emissions but also take into account consumption-based emissions without hav-
ing to make a final decisions where the exclusive focus must lie. It can also
make sense to help boost production-based mitigation contributions by means
of consumption-based approaches.

The more information on carbon emissions is available, the more it makes

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8Expert statement at Overseas Development Institute workshop on “Certification as a route
to reducing the global carbon footprint: Implications for developing countries.”, London,
3rd September 2019.
12.3. Embodied emissions policies within the context of a global polycentric governance structure

sense to use this information for policy, which, in turn, increases incentives for providing information. In this way, a virtuous cycle can come about. Where environmental regulation in one jurisdiction helps to improve the data basis for regulation in another jurisdiction to draw upon, a public good is produced. Those who contribute elements to this virtues cycle may be said to contribute to the emergence of a global public good. From this perspective, such information-releasing policies appear as contributions to a polycentric informational governance structure.

Following Hess and Ostrom (2003, 117), one could says that California has doubly contributed to the provision of a global public good. It has introduced a rule of how to deal with embodied emissions in a specific, limited sector (second public good layer). This may be only a limited and preliminary rule, which will most likely be subject to later adjustments. However, it may serve as a model, positive or negative, in the unfolding debate about suitable policy instruments that can be adopted at the level below larger units such as the EU or the USA. Second, as the Buy Clean California Act encourages the creation of information on the carbon emissions embodied in products, it also contributes to the generation of information as a global public good (third public good layer).

There is room for interpretation as to the extent to which rule creation should be interpreted as contribution to a public good. Whether rule creation itself really contributes to a public good would need to be seen from the perspective of actual outcomes (first public good layer) and would thus only be possible to identify post hoc.

An alternative to the individual accounting at the product level could be to establish ‘carbon clubs’, where countries with a similar carbon price can guarantee the unhindered flow of their products among their members. However, such arrangements would take impetus away from product-level accounting, which would weaken the sanctioning potential of unilateral consumption-based policies.

Furthermore, similar to the joining of carbon markets, there is the danger of establishing an association, which from then on will be subjected to the logic of lowest-common denominator decision-making, which may seriously impede ambitions. Seen from this perspective, polycentric governance relying on the backup of sanctions in the form of consumption-based policies may potentially be able to outperform purely consensus-based systems which rely on a mutual balancing of emission reduction obligations. The polycentric approach has the
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virtue of letting pioneers not just cut emissions more radically than others but also to provide their trading partners with incentives to swiftly follow them.

12.4. Significance of findings and policy relevance

It is useful to demonstrate the significance of the findings of the empirical chapters with a series of counterfactuals: Without the expectation that there would be a price on carbon, or other carbon-constraining policies, there would have been less incentives for private standard-setting in the area of GHG measurement and reporting (see Section 9.4.1). Without the establishment of energy efficiency performance standards for buildings and their legitimation in climate mitigation terms, there would not have been a plausible target for the embodied emissions coalition to demand something tantamount to the conversion of the energy efficiency standards institution to a whole-life carbon standards institution (see Section 6.4.3). Without the establishment of EPDs, it would be more difficult to argue for the technical feasibility of embodied emissions standards. Without standardised GHG measurement and reporting, EPDs’ carbon values may not be comparable (see Chapter 7).

Could one imagine the supply of EPDs emerging without demand for them? Certainly. Companies may well have wished to use EPDs as a marketing tool and some corporate strategists may have speculated that EPDs may be used for government regulation or procurement at some time. Could we imagine the supply of EPDs without any prior demand for environmental data at the level of facilities or firms? It certainly is possible to only start measuring and reporting data in order to produce an EPD.

There are usually different ways to obtain the same result. What have been real existing factors supporting the emergence of EPDs may not need to be theoretically necessary as different causes can be sufficient (on sufficiency and necessity see Mahoney, Kimball, and Koivu 2009). However, just because production-based monitoring and reporting may neither be necessary nor sufficient for product-based disclosure to arise, in general, it does not mean that it is inconsequential for it. For many phenomena, the important question is not just whether they are linked to antecedent phenomena via relations of sufficiency or necessity but to which extent their emergence, development and diffusion is supported by the presence of the antecedent phenomena. In complex open systems, time matters, and different initiatives vie for attention and resources. For
standards, be they for products or procedures, for objects or behaviours – for common perceptions of the world – to establish themselves, a critical mass of actors is needed to support them. The presence of supporting conditions for this can be an important factor in whether standards and norms manage to become established and entrenched, or decline.

The speed at which change occurs is an important matter in climate politics, and therefore in its analysis. If consumption-based approaches are rolled out quickly, they have the best chance to make a difference. If time did not play any role, one might well say that it could suffice, for the moment, to rely on renewable energy and energy efficiency policy and not address carbon directly for buildings. Instead, one could wait until buildings approach nearly zero operational emissions, which might then open up demands to also look at embodied emissions. At such a point, the demand for product level information might be sufficient to progressively elicit more and higher quality information. Yet, without a prior data basis, which can be helped to create by stimulating demand for EPDs, this would likely take much longer.

This study has important implications for the strategic prioritisation and evaluation of initiatives, programmes and policies in climate politics (on valuation of governance initiatives see Section 3.1). Amongst the initiatives Bakhtiari (2018) evaluates are CDP and the CSI. CDP is attributed an estimated emissions reduction potential of 1.30 Gt CO$_2$e until 2030 via the “implementation of the commitment by a group of companies accounting for about 15% of all corporate emissions of greenhouse gases would result in savings of about 0.7 Gt CO$_2$e in 2020 and 1.3 Gt CO$_2$e in 2030, compared to a reference scenario” (Bakhtiari 2018, 658). The CSI is attributed an estimated emissions reduction potential of 0.10 Gt CO$_2$e until 20130 via “a voluntary GHG emission reductions commitment by 24 major cement producers” (Bakhtiari 2018, 659).

Such evaluation parameters, in accordance with what one may call the ‘timetables and targets’ paradigm, clearly do not take into consideration that the CDP’s collaboration and synergies with GRI (Global Reporting Initiative, n.d.) and its use under the Global Compact’s Communications on Progress (see e.g. LafargeHolcim 2017) may have helped to feed into and support the feasibility of reporting under the European Directive on disclosure of non-financial information (see Section 9.4.1), which in turn has increased demand for experts, who are likely to also possess LCA relevant knowledge. Nor would they consider how the work of the CSI has helped to improve the availability of carbon benchmarking
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data for EPDs (see Section 8.5).

Other suggestions for evaluation frameworks emphasise the need for clearly defined outputs (as reviewed by Van der Ven, Bernstein, and Hoffmann 2017, 5). While the above examples could perhaps be appropriately evaluated with such a framework, it would still fail to adequately assess those indirect effects which cannot be clearly delineated *ex ante*.

Overall, the present study strongly supports the need for valuing the contribution of policies and governance initiatives with a framework that allows to account for dynamic and interactive effects that may often only play out over time. A low carbon price may be ineffective when it comes to immediate decarbonisation efforts, but it can help to build capacities, not only for an eventually higher carbon price, but also for consumption-based measures. On the one hand, consumption-based measures can reduce carbon leakage and thus permit more ambitious climate action at the domestic level. On the other hand consumption-based measures can help to mobilise alliances for more expansive regulation, thus helping to overcome lock-in.

Evaluations of non-state actors' contributions to the climate regime need to take into account second and third order effects, which, in this case, can be expressed in terms of *layering* and *conversion*. Policy-makers and advocates should consider how incremental ‘layering’ can lead to accumulating changes over time and thus help to break ‘lock-ins’ (see Levin et al. 2012; Bernstein and Hoffmann 2015). While in hindsight preconditions or supporting factors can indeed be reasonably well identified, the challenge would be to utilise such an analysis for forward-looking policy interventions. Such forward-looking efforts should seek to realise the potential of layering activity within the context of polycentric governance to improve the preconditions for mutual monitoring and sanctioning mechanisms with the aim of moving the atmosphere towards a jointly managed common property regime.

Whole-life-cycle carbon standards or embodied emissions procurement criteria (second public good layer) can be adopted at multiple scales and – crucially – at lower scales than carbon pricing. They have multiple attractive points going for them:

- they can reduce the consumption of embodied carbon directly in accordance with their stated aim (first public good layer),

- they can help to contribute towards the informational infrastructure for
12.4. Significance of findings and policy relevance

- they can help to provide examples or prototypes for sustainable housing, infrastructure and mobility, which can be adopted in other places, thus indirectly helping to reduce emissions and creating more of a constituency which could advocate for those standards and policies that help to increase demand for their products and services (asymmetric co-benefits).

The role of green buildings councils – whose private authority is sometimes propped up by public support in the form of conditional tax deductions or by serving as a model for government certification systems such as the BNB – shows how potential regulations could be implemented at lower levels of government (see Chapter 6). This allows more piloting of regulatory solutions at a niche level than carbon pricing schemes. This also points to the potential for polycentric action, where a range of different actors at different levels can effect changes in the informational attributes of commodities, onto which other, more demanding private initiatives and public policies can then layer on. A range of alternative policies to carbon pricing are used to incentivise more energy efficient buildings and vehicles. Amongst these are public procurement, tax incentives, standards and government loans (in the case of buildings). Many of these policies can be adopted at lower levels of government. In addition, the continued Buy Clean California campaign now targets the city and county level (Sierra Club California 2018a) and thereby demonstrates the potential for lower level entities to contribute towards the global climate change regime complex by stimulating the diffusion of PCFs as part and parcel of EPDs.

Technology and material-neutral policies are more in tune with prevailing norms of ‘liberal environmentalism’ (Bernstein 2002), and are more likely to withstand collisions with free trade norms, than policies which could be perceived as arbitrarily discriminating among technologies or materials. It has become part of the neoliberal canon that government should avoid picking winners (see e.g. Helm 2010, 195; for a critical perspective see Azar and Sandén 2011). For example, in the domain of building policy the German Federal Government has time and again stated that it seeks to make sure policies do not privilege specific technologies or materials (German Federal Government 2015b, 2015a, 2016). In principle, WTO rules could permit the introduction of measures to limit the importation of embodied emissions (Bleischwitz and Bringezu 2007, 10). However, as of yet, while there is the possibility that border carbon adjust-
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tments are already legally viable under WTO law, there is still no legal certainty (Bachus 2018, 13; Das et al. 2018, 48). Still, policies that affect trade on the basis of ‘non-discriminatory’ principles stand a better chance of holding up in front of WTO tribunals (Kaufmann and Weber 2011). It is precisely this space between a compatibility ‘in principle’ and actual legal uncertainty, which confers particular value to measures that help to prepare the institutional and epistemic foundations for the measurement of carbon embodied in trade, in a way that does not need to fall victim to a binary situation where an eventual clash with the WTO would devalue all prior efforts and demotivate future action.

Current tendencies towards an erosion of the liberal trade order, even if mainly limited to rhetoric, may present a window of opportunity for the introduction of principled, non-discriminatory trade restrictions on carbon intensive goods. In the case of steel, this could be particularly attractive as the introduction of carbon tariffs by, e.g. the European Union, should be able to generate support amongst US steel interest, while being able to stem Chinese imports.

For Vogel (1997, 567f.):

“The key to effective environmental governance at both the regional and global level is the commitment of rich countries: they must be willing both to change their own policies and provide less affluent or green countries with sufficient incentives to modify theirs as well”.

Measures targeted at embodied emissions may work analogous to product standards and thus have the potential to generate a ‘California effect’, as suggested by developments in, well, California. The adoption of embodied emissions policies in rich countries would provide incentives for less affluent countries to increase their own efficiency. Ideally, however, such a policy would go beyond forcing the efficiency of carbon intensive sectors (as under the Buy Clean California act) and start pitching different materials and business models against each other, with the aim to not just improve the carbon efficiency of rich countries’ consumption but also to reduce their carbon consumption overall.

As suggested by Vanderborght, third party verification in some countries might not be reliable. Here the question arises whether it would not be more prone to corruption to rely on private parties rather than on governments, who – it is hoped – are concerned with their reputation more long-term. However, EPDs also serve to make different materials comparable. While misleading

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9Interview with Vanderborght.
claims might serve to make the environmental qualities of some products appear better compared to similar products, the range of credible deviations from the norm might not be too big for subverting the contest between different materials in terms of embodied emissions.

For climate politics to be successful, it is important to not only have industrialised countries but also developing and emerging economies on board. Some of these may be characterised as ‘information-poor’ environments (Mol 2014, 44), with different institutional conditions than in Western democracies. In order to better understand how these countries can be integrated into efforts to transform the current regime, it is crucial to first gain clarity over the drivers for the emergence of what may be deemed a polycentric governance ensemble which — through providing standards, protocols and information — is starting to provide the basis for regulating emissions embodied in trade.

One may question whether a carbon constraining policy targeting the firm level would be necessary or whether a direct ‘leapfrogging’ towards product standards might be possible. Once the institutional infrastructure for product carbon footprinting is in place, such a direct adoption, without the ‘detour’ via firm level measures may certainly be possible. However, historically and, still, today, instruments directed at the firm level have been instrumental in stimulating product-level disclosure. This also allows a better triangulation between production and consumption-based data.

Does it even matter, whether the LCA field historically benefited from data intensive environmental policies at the production level to a significant extent, now that EPDs have come about and there might be a self-sustaining momentum of mutually converging expectations? The question is still relevant as there are little guarantees for data quality and reliability and there are strong possibilities that some LCA consultants and verifiers will cook the books, and a scandal might break out, undermining the legitimacy of relying on EPDs for regulation. If one solely depends on the demand-side for bringing about LCA information, and production-based regulation does not elicit it anymore, one may lose a way of triangulating the information and thus checking its plausibility. Moving to an entirely consumption-based policy framework would reduce the possibilities for such a triangulation. This suggests the desirability of replicating policies which can be used to triangulate the information available.

Incentives for presenting performance data at the sectoral level for ETS benchmarking and EPDs seem to run into opposite directions. If sectoral performance
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benchmarks are ought to provide governments with information on abatement potentials in order to set realistic targets, industry should have an incentive to portray its initial performance as worse than it is, in order to lower expectations. Later, it should have an interest in talking down its abatement potentials. In contrast, when it comes to LCAs and EPDs, industry should have an interest in producing numbers that emphasise the good performance of its materials, relative to other materials. As companies should have opposing incentives in the reporting of maximum achievable performance under ETS benchmarking and under EPDs, the combination of the two policy instruments can jointly lead to a better information supply for regulators. From the perspective of polycentric governance theory, this could be seen as another instance of (partially) redundant institutional arrangements providing advantages over parsimonious solutions (see e.g. Dietz, Ostrom, and Stern 2003).

There is the danger that the internal procedures and third-party assessment and verification needed for the creation of EPDs may disadvantage smaller companies or developing countries (for a general discussion see e.g. Mol 2014, 45). The same goes for the actual carbon reduction efforts, be they at the level of basic products or complex ones. This may exacerbate existing structural inequalities and ways to address this should be taken into account in policy design.

What this study contributes to the literature on orchestration and polycentric governance is the empirically supported proposition that measures targeted at increasing carbon commensurability, via monitoring and reporting requirements, can help to catalyse the emergence of novel economic actors with an interest in introducing or ratcheting up policy instruments targeted at embodied emissions, or changes in the positions of established actors to that end.

Ideally, policies for a more sustainable development should not just be effective but also be characterised by the features that their properties are likely to help build and further entrench support for them. They should also, over time, have a high probability that the population they cover expands and that it will be replicated in other places (Levin et al. 2012). Only recently actors have started to rally behind performance standards that include embodied carbon. Yet the way that diverse actors can rally behind the unifying banner of ‘embodied carbon’ or ‘whole-life-cycle emissions’ and the expertise they can contribute to the policy-making processes suggests the stakeholder-mobilising properties of such policies. As such policies rely on PCFs, they also create demand for
their production, which promotes the further diffusion of PCFs. This can also support the diffusion of the policies drawing on them. What can be seen now in the building industry has a great potential to extend to the areas of vehicle construction and agriculture (see Section 5.6).

There is a potential for the uneven diffusion of product carbon footprints, the policies drawing on them, and the coalitions supporting them. Ideational and trade linkages may support this diffusion, in a manner analogous to the California effect. This polycentric ensemble of actors providing and demanding information may ultimately lead to a qualitative shift in the capacity of actors at multiple levels and locations to engage in mutual monitoring and sanctioning.

Policy-makers should increase the incentives for EPD/PCF adoption via a mix of standards and procurement criteria and provide more support for the generation of LCA knowledge. In the mid-term they should make use of the proliferation of PCFs and EPDs to introduce border carbon adjustment schemes. However, they may wish to already utilise windows of opportunity arising from other actors’ protectionists measures in order to reciprocate with principled carbon tariffs rather than with purely retaliatory counter-actions. The further roll-out of PCFs and EPDs could then be pursued in parallel to fine-tune the system and, over time, include more product groups.

In line with Ostrom (2014a, 182f.), and Dietz et al.’s (2003, 1909) endorsement of graduated sanctions, it would probably make sense to phase in consumption-based instruments such as BCAs beginning with low costs and then raise the costs gradually over time.

12.5. Limitations of study

This study is necessarily limited as I explore a wide range of closely interrelated issues from a novel angle. Any one of the empirical chapters would be deserving of a more comprehensive treatment, with a more sophisticated research design and more data brought to bear. However, standing by itself, the relevance of any one chapter, even if brilliantly executed, would not be obvious. Only by connecting the different aspects making up the elements of the informational governance of embodied emissions, and the politics associated with it, does it becomes clear how these developments have contributed to improving the prospects for turning the atmosphere into a jointly administrated common property.

The design of rigorous research programmes on the issue at hand becomes
severely complicated as there are good reasons to assume that informational push and pull factors are present at the same time. Attributing causal effects to informational push factors thus becomes severely complicated – just because the prior availability of information and institutional infrastructures lowers the costs for creating PCFs packaged in the form of EPDs, it does not follow that the EPDs would not have been produced without the prior availability of such information. However, they would certainly have become much more expensive, which should have slowed down their diffusion.

Similarly to other areas of study, the transnational nature of the phenomenon in question reduces the explanatory power of neatly set-up comparative research designs. While I did engage in cross-national comparative analysis, rigorous findings with the potential to be endowed with predictive power are largely limited to the tenets that whole carbon standards for final products and benchmarks for intermediate goods will gain distinct groups of supporters and that the prior adoption of energy efficiency schemes is likely to provide an institutional, epistemic and discursive basis for embodied emissions demands to piggy- back onto.

12.6. Opportunities for further research

There are a range of other plausible causal mechanisms, which I have not considered, largely because of the difficulty of examining them empirically within the scope of this research. In Chapter 9 I focus largely on how resources are mobilised towards the build-up of cognitive capacities. The study of normative change, in contrast, would also merit an in-depth investigation. A potential major causal mechanism is hardly palpable: the diffusion of environmental concerns, including knowledge and norms, may drive both production-based as well as product-based monitoring and disclosure. Taking this into account, one may well be tempted to attribute diminished causal power to spillover effects. However, in response one may ask whether it makes sense to conceptualise environmental concern as entirely exogenous to the associated practices. Environmental concern is not just transmitted in a disembodied form by educational institutions, civil society, and the media. Practices can also help to diffuse their underlying norms and rationalities.

A DGNB representative suggested that product level environmental disclosure would be a logical next step after corporate level disclosure, which is demanded
This could be a kind of normative spillover effect. Here, I use the term normative both in regard to ethical expectations as well as in its relation to processes of normative standardisation and everyday normalisation. Once one transparency norm is established, one could suspect that it becomes expected behaviour and normalises disclosure activity, in general. One hint that such a spillover effect is indeed at place would be the joint consideration of product and organisation environmental footprints by the European Commission (2013).

This also points towards a double relation between initiatives such as the GRI and EPDs. Where commercial intermediaries pressure firms into releasing more information, they may normatively contribute towards a furthering of expectations towards disclosure, which may then also benefit the legitimacy of the idea of EPDs. Functionally, or practically, they may also exert pressure towards greater information availability at the firm level, and they provide background data for LCA databases.

That such a normative rescoping would occur seems intuitively plausible. Its empirical testing seems to be challenging, to say the least.

The analysis of the CDP data in Chapter 9 was limited to cross-sectional data. Future research could make use of the successive iterations of the CDP survey and analyse a select set of industrial sector in a longitudinal fashion. This would probably be better suited for capturing change over time.

With regard to green building schemes one could argue that they have a lot of discretion over the extent to which they consider embodied emissions, which might make delegation to them an interesting option for bureaucrats or policymakers who wish to shield themselves from veto-players. Yet, the extent of discretion that pro-embodied emissions fractions enjoy within the organisations that administrate green building schemes remains an issue for further, more micro-level research. Anyone who wished to study orchestration processes in the area of embodied emissions governance would do good to consider these institutional dynamics.

I inferred the motivations for coalition membership by analysing co-membership in different organisations (see Section A.6 of the Appendix). Further research could help to triangulate my results by establishing the individual motivations of different material suppliers and service providers through in-depth interviews.

This study has focused on empirical developments and has only scratched

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10 Interview in 2016.
12. Discussion

the surface of a more abstract political-economic analysis of the interest structures under different embodied carbon policies. A more systematic modelling of such interest structures for different sectors and countries could help in better planning the design and sequencing of policy interventions.

This thesis also suggests interesting areas of research concerning the questions of how polycentric climate change governance may, first, benefit from its ability to circumvent veto players and, second, from the diminished identification of specific non-state actors with the states sponsoring them.

12.7. Outlook

About 20 years ago Vogel (1997, 565) observed that “[n]either policy-makers nor consumers in rich countries appear willing to bear the significant economic costs of imposing restrictions on the substantial number of imports from developing countries that are produced in environmentally damaging ways”. The question is whether this still holds for today’s battle against climate change.

I have shown that there are good reasons to assume that the political dynamics of product based carbon policies should differ from production-based ones, which is a reason for investing hope in their potential for advancing towards a more effective climate change polycentric governance that may eventually achieve to turn the atmosphere into a jointly managed common property.
13. Conclusion

What is the role of information in global climate change governance? What is the significance of the informational externalities emanating from diverse polycentric policies and initiatives?

This thesis has provided detailed evidence that information production has catalysed commensuration processes, which have ushered in new dynamics of coalition building in the area of climate policy. Policies and initiatives aimed at measuring and regulating environmental pollution have provided the raw material for processes of carbon commensuration to succeed. Such commensurability enables new policies, with modified political opportunity structures. Such modified political opportunity structures allow novel coalitions to identify themselves as such and mobilise in the name of climate change mitigation and for a common cause.

Those who aspire to a deep understanding of the dynamics underlying the evolution of the climate change regime complex need to broaden their perspective to encompass other environmental issues. Scholars who only focus on PCFs miss out on how the development of the wider field converging around EPDs conditions the availability of the PCFs contained in them.

A novel policy type in the form of product standards taking into account embodied carbon emissions is emerging. While California has announced the introduction of such a standard in the form of minimum carbon efficiency procurement requirements for certain intermediate products, some private green building certification schemes already take into account embodied emissions, and there are business coalitions advocating for the introduction of mandatory building standards taking into account embodied emissions.

The availability of new embodied emissions policies opens up opportunities for the mobilisation of actors for more ambitious climate action in terms of economic incentives, participation, and group formation. A particularly relevant feature of product standards taking into account embodied carbon emissions is the way they can garner business support: Chapter 5 provided good evidence
13. Conclusion

for the proposition that information on product life cycle emissions facilitates relatively low carbon businesses to re-aggregate behind the low embodied emissions framing. It also specifies and empirically validates how different embodied emissions policy designs muster the support of different constituencies, with benchmarks for intermediate products garnering support from relatively carbon efficient producers within potentially high carbon product classes, whereas downstream standards for final products receive support from producers of low carbon product classes and service providers.

Carbon commensuration processes, enabled by product labelling and LCAs, can provide the informational foundations for businesses and advocates to complement more specific, qualitative, sustainability framings, such as ‘renewable’ with the quantifying one of ‘low embodied carbon’. This allows diverse producers and service providers to re-align behind a common framing for their demands. In relation to the aim of global warming mitigation, the framing of ‘zero carbon’ or ‘low carbon’ can be regarded as more broad and universal and more immediately related to the environmental impact than more particular, product-focused framings such as ‘renewable’ or ‘recyclable’.

Policies and initiatives aimed at measuring and regulating environmentally relevant flows in production and consumption have led to catalytic sequences where commensuration processes involving normative change and capacity building ushered in new dynamics of coalition building in the area of climate policy. Chapter 6 shows that energy efficiency policy has indirectly helped to create demand for information on embodied emissions and thus to improve the political, institutional, technical and epistemological conditions for the governance of embodied emissions, which may yet help in including consumption into climate policy. Here, processes of normative change were important as building policies and initiatives were already justified with reference to environmental concerns, whereupon advocacy for the inclusion of embodied emissions could layer onto or seek to convert existing energy efficiency-focused policies and initiatives into carbon efficiency ones.

Chapter 7 shows that the availability of standardised quality information on embodied emissions is an important criterion for the legitimacy of policies addressing embodied emissions. This makes the availability of standardised quality information on embodied emissions an important resource for the advocates of a greater role for embodied emissions in policy. In consequence, this information can be usefully conceptualised as a public good, which can enable the establish-
ment of further public good layers in the form of polycentric monitoring and sanctioning mechanisms at trans- and international levels.

Chapter 8 shows that environmental policies that rely on deliberation and coordination between government and industry peak organisations provide incentives for companies to engage in the sectoral sharing of environmental data. Furthermore, the sharing of such data, and the establishment of institutions for this purpose, should reduce the transaction costs for the creation of sectoral EPDs and thus be conducive to the diffusion of labels that inform about the environmental impacts embodied in products. Here, one can see that specific pressures different industries are exposed to lead to a polycentric clustering of informational institutions. Once these have established mutual trust and monitoring processes in relation to government pressure, these can be utilised for the creation of product level information.

Chapter 9 finds good evidence for the proposition that production-based environmental monitoring and reporting has spillover effects and thus drives down various costs for eventual product level disclosure of life cycle impacts. Material, institutional and cognitive pathways for the spillover from capacities for production to product-focused environmental monitoring and reporting are all important.

Chapter 10 provides tentative evidence for the proposition that energy efficiency and/or carbon policy indirectly help to generate higher quality carbon footprint data as they stimulate the diffusion of better energy metering equipment. This is an additional channel for these policy types to stimulate the creation of PCFs and EPDs.

Chapter 11 shows that diverse polycentric policies and voluntary initiatives that stipulate environmental monitoring and reporting provide important data sources for LCI compilers. Furthermore, the significance of these data sources for the overall availability of data sources needs to be assessed in a way that does justice to the potential conjunctive and cumulative effects, i.e. the possibility that in themselves unreliable data may still be used for triangulation purposes and that rough, ‘conservative’ estimates can be used to elicit more data from companies. That chapter also shows that it is precisely what may be perceived as the failure of policies to perfectly delegate away the need for information gathering via supposedly elegant market mechanisms that helps to generate information, which can later be used to come up with estimates on the embodied environmental impacts of products.
13. Conclusion

Contrary to some authors who identify eco-labelling with privatised governance, this thesis has shown that government actors have actively supported the development and diffusion of PCFs and EPDs and that these eco-labels have a significant potential for becoming the building blocks of government policies. This shows the importance of adopting a non-zero sum and dynamic perspective for a context-specific understanding how of eco-labelling interacts with reconfigurations of the public-private relation.

This thesis demonstrates how polycentric governance practices have helped to increase the feasibility of introducing consumption-based policies targeting embodied emissions, which may eventually help to provide global climate change governance with the missing elements of decentralised sanctioning mechanisms. By leaving standard-setting to transnational networks comprised of diverse actors, governments have been able to support standard-setting processes and the adoption of PCFs and EPDs in a way that has benefited from three interrelated features: first, the delegation of standard-setting to private actors and the, initially, voluntary nature of standard adoption can help to insulate standard-setting processes from veto-players within government or parliaments. This provides a kind of protected niche for standards to mature. Second, by limiting its own role government leaves space for a variety of actors to enter into complementary relationships. This can help to generate a constituency which can benefit from the further entrenchment of embodied emissions governance and thus has incentives to advocate for it. Third, it can help to extend activity beyond national boundaries as private actors can spatially extend activity in a way that may be seen as improper if it were done by a foreign government. Potentially, there is a fourth feature which may yet prove to be beneficial: the association of PCFs and EPDs with business practices rather than government intervention may ease its integration with the world trade regime.

From an informational-institutional path-dependency perspective the relation between standard-setting and pricing mechanisms is more dynamic and complex than a characterisation in term of alternatives or complements: the anticipation and actual introduction of carbon pricing mechanisms have helped to diffuse practices and technologies for making acts commensurable in carbon terms. This has improved the conditions for distilling such information at the product level, which, in turn, could allow regulation in the form of embodied emissions

\[\text{However, veto players from business may exert power more directly in standard-setting bodies.}\]
standard-setting to draw on such information, and to create further incentives for the diffusion of PCFs. Once these become more widely available, border carbon adjustments could draw on these, which would make ambitious carbon pricing more viable.

When considering the novel element of embodied emissions standards, we can also appreciate another dimension of the relationship between standard-setting and pricing: often economists praise pricing mechanisms over standards for pricing’s supposed ability to exert effects in a technology and material neutral way. As real existing carbon pricing fails to live up to that aspiration, downstream product standards that incorporate embodied emissions offer more hope for fulfilling that promise. In addition, as such downstream standards may help to increase demand for PCFs and EPDs, which may ultimately be able to improve the conditions for border carbon adjustments, they could well end up helping the promise of carbon pricing to realise, too.

Altogether, this informational perspective on the institutions of environmental governance, and their implications for the global governance of embodied emissions, provides a novel, holistic perspective with very concrete implications for the valuation of different policies and initiatives. Policies and initiatives that help to improve the conditions for the production of information on the carbon footprint of products can, indirectly, contribute towards making the governance of embodied emissions more feasible, and thus, potentially, help to improve the global governance of the atmosphere. From this perspective, small acts at the local level, like incentives for the use of sustainable buildings rating systems which, in turn, provide incentives for the use of EPDs, can accumulate to improve the basis for global climate change governance. Energy efficiency measures can help to prepare whole-life carbon standards and thus criteria for rewarding more carbon efficient building practices and materials. In addition, they can help to diffuse energy measurement technology, which can facilitate the creation of higher quality PCFs. Lastly, the availability of information on embodied emissions for novel product standards has the potential to significantly change the conditions for the formation of pro-regulatory coalitions in the area of climate policy.

If knowledge helps to exert power and information is a basic element of knowledge, powerful institutions for climate change mitigation can be crafted through the purposeful layering of one informational institution onto another. The construction of knowledge and information-intensive institutions at the level of
buildings has helped to elicit information on the carbon intensity of building materials from their producers. This, in turn, has increased the feasibility of policies targeted at embodied emissions, the adoption of which would partly shift the locus of climate politics from upstream production to downstream use. By shifting the locus of policy, and thereby politics, different stakeholders will be endowed with epistemic and political competencies in policy discussions. This shift in who is considered a legitimate stakeholder in policy between up- and downstream loci of intervention also coincides with a re-arrangement of group identities in relation to the proclaimed targets and the differential effects of policy. By engaging in the construction of institutions that produce knowledge, information, and standards, actors can thus manage to transform climate politics. This mechanism has a great potential for successful application in other areas of climate politics, in wider environmental politics, and in other informationally intensive fields.

Drawing lessons from the insights in this thesis, climate policy experts and policy-makers should adopt a holistic perspective on the informational conditions for the establishment of mechanisms for mutual monitoring and sanctioning in a world in which important players do not wish to cooperate. We can see that diverse polycentric policies and initiatives have contributed to the emergence of institutions of mutual monitoring at the product level, which may eventually form the basis of another layer of decentralised mutual sanctioning mechanisms with the potential of helping to move the atmosphere along the continuum from a state of open access to that of a jointly managed common property. Multiple actors at different places and levels can adopt a variety of policies that all contribute towards advancing carbon commensurability and the informational infrastructure for addressing embodied emissions. This can help to ensure that progress can even be made in the face of a lack of cooperation by important actors.
99,973 words
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A. Appendices

A.1. Publications

- Submitted to *Global Environmental Change*: Nino David Jordan: Embodied emissions policies – design options and political mobilisation potential; based on Chapter 5

- Revise and resubmit from *Environmental Science & Policy*: Nino David Jordan: Spillovers from place-based environmental reporting to labels; based on Chapter 9

- Revise and resubmit from *Organization & Environment*: Nino David Jordan: ‘We’ve got that data already’. Industry sector environmental accountability and EPDs; based on Chapter 8

- In preparation for *Global Environmental Politics*: Nino David Jordan: Energy efficiency as a catalyst for the governance of embodied emissions; based on Chapter 10
A. Appendices

A.2. Coded segments of CDP survey

A.2.1. Data description

In the following I present quotes from the CDP Investor dataset 2015, where companies indicated their responses to emissions reporting obligations.

I present quotes indicating that (a) reporting obligations improve data within companies, that (b) specific systems or technologies are employed in response to reporting obligations, and that (c) human resources need to be allocated to the emissions monitoring and reporting implementation and process in response to reporting obligations. Category a is split into responses to opportunities and risks, as the difference between the two rubrics was particularly striking.

For convenience reasons, particularly relevant sections are in bold type.

Sometimes the statements are ambiguous and I had to make significant assumptions in order to categorise the statements as indicating that reporting obligations help to improve the data basis. Where I found that I had to make such as assumption, I have sought to document these.

A.2.2. Reporting obligations improve data within companies as response to regulatory opportunities

1.

“Improvement in emissions management, reporting and monitoring via reporting under the NGER scheme. ... Through participation in the NGER scheme we monitor reductions in energy consumption and emissions.”

*Aurizon Holdings*

2.

“Our obligation to report under the NGER Act (and repealed Energy Efficiency Opportunity (EEO) Act) in Australia has led to significant improvements in our energy and greenhouse gas data management that we have now rolled out across our global operations. This improved oversight has allowed ANZ to set targets relating to the identification and implementation of cost-effective avenues to reduce energy use and carbon emissions, leading to significant savings in 2014 that will be extended into future years.

*Australia and New Zealand Banking Group*
3.

"UK Mandatory Reporting Regulations; NGERS
Reduced operational costs"

_BAE Systems_

Here I made the assumption that if emissions reporting obligations reduce operational costs, this would likely be via data improvements, which then result in the detection of opportunities for efficiency improvements.

4.

“The opportunity here lies within the fact that **through reporting on emissions areas can be identified where emission reductions can be implemented.** Such reduction initiatives will essentially translate in to cost savings.”

_Basil Read_

5.

"Although the Bank is yet to reach the GHG emissions threshold for mandatory reporting under the National Greenhouse & Energy Reporting Act, we have undertaken a significant amount of work to capture the quality of GHG emissions data available for future reporting.

This activity presents the opportunity for emissions and cost reduction, driven by better understanding of emissions, in turn driven by regulated reporting requirements.”

_Bendigo and Adelaide Bank_

6.

“Emission reporting regulations include the British Columbia: Greenhouse Gas Reduction (Cap and Trade) Act Reporting Regulation. The **level of detail required to collect data for assessment is significant.** This has presented a **better understanding of our emissions** within the province and opportunities to reduce expenditures.”

_Bonavista Energy Corporation_
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7.

“Compliance with legislation such as the UK Mandatory Reporting Requirements and the UK Carbon Reduction Commitment provides BAT with the necessary drivers to reduce our primary energy consumption, thus improving operational efficiencies and profitability.”

*British American Tobacco*

Here, only the response to the first policy points to the inducement of better data, the latter policy could also drive improved efficiency in a case where data was already good but not much action taken on it.

8.

“... the implementation of a comprehensive carbon accounting system across Capgemini has provided the business with detailed insights into its environmental impacts and the associated costs of energy, business travel and waste. ... This has enabled the implementation of targeted initiatives with the dual benefit of reduced cost and reduced environmental impact.”

*Cap Gemini*

9.

“We have begun reporting our emissions at a time when it fits with our other strategic planning priorities. This is helping us to reduce our operating expenses on freight, water and energy–putting us, potentially at a strategic advantage over our non-reporting competitors”

*Chicken of the Sea Int'l*

Here I assume that the operating expenses could be reduced due to the novel data that became available via emissions reporting.

10.

“Emissions reporting obligations would require Coach to more accurately measure and manage our footprint and help us identify areas to improve operational efficiency, reduce emissions, and create cost savings.”

*Coach, Inc.*

11.
“The savings associated with emissions reporting and implementation of energy conservation projects across our manufacturing sites globally could be over $425 million in avoided costs in the coming years, based on our estimate of prior savings from the period of 2002 to 2014. Additionally, sustainable and efficient logistics projects around the globe have removed over 3,000 tons of carbon from our distribution network and deliver an estimated $3.5 million in annual savings.”

Colgate Palmolive Company

12.

“The number of mandatory emissions reporting obligations e.g. National Greenhouse and Energy Reporting (NGER) scheme in Australia, supports the improvement in quality, reliability and transparency of the Group’s Greenhouse Gas (GHG) emissions reporting. This enables cost efficiencies when identifying and managing climate change related risks.”

Commonwealth Bank of Australia

13.

“Mandatory Emissions Reporting under the Companies Act 2006 (Strategic Report and Directors’ Report) Regulations 2013 will allow us to better understand our carbon risk.”

Communisis Plc

14.

“The cost of reporting is an additional burden on our U.S. operations, but we have found savings through energy management projects and realize enhanced value to our reputation of participating in the above referenced registration systems.”

Dean Foods Company

Here I assume that these energy management are directly informed by the improved data basis that results from the monitoring and reporting activity.

15.
A. Appendices

“DENTSPLY continues to measure and report on its GHG emissions. This allows us to more efficiently manage our energy use, reduce operating costs and GHG emissions, and adapt to changing environmental conditions, all of which may increase DENTSPLY’s competitive advantage.”

*DENTSPLY International Inc.*

16. “Compliance with the NGER Act enables DEXUS to critically examine reporting structures, better measure trends and set up more efficient tracking systems. DEXUS sees an ongoing opportunity to improve efficiency and data accuracy, identifying billing errors, conduct competitive energy procurement, reductions in emissions and ultimately lower operating costs across the properties and the business.”

*Dexus Property Group*

17. “Regulations that require the disclosure of data present an opportunity for Diageo to obtain competitive advantage. Through our robust and long-term commitment to emission reporting and reduction, we have been able to develop a deep understanding of our carbon profile. This, in turn, has helped us to identify carbon hotspots and to drive efficiency, making us more competitive.”

*Diageo Plc*

18. “Cost savings can be achieved through monthly tracking. One example was a paper switch to a less carbon intensive product. This resulted in 123 tonnes CO₂ saved and added benefit of a R24 000 monthly saving and saving on quantity of paper required due to less damage and loss from superior quality paper.”

*Discovery Holdings Ltd*

19. “Increased emissions reporting helps to further understand the energy usage within the company.”

*DOF ASA*
20. "Reporting of GHG Emissions under EPA’s mandatory GHG reporting rule identifies opportunities for reduction of emissions."
   \textit{DTE Energy Company}

21. "Increased emission reporting obligations could cause additional analysis of energy and carbon-reducing opportunities in our direct operations and (indirect) supply chain."
   \textit{Eli Lilly & Co.}

22. "British Columbia: Greenhouse Gas Reduction Act Reporting Regulation. This regulation requires a level of data collection more detailed than the other jurisdictions in which we operate. Specifically, we have a detailed understanding of our emissions sources that has allowed us to evaluate other carbon offset project opportunities not previously recognized. Further, we capitalized on the opportunity to increase the detail of our inventory and measured data for source points not previously measured."
   \textit{Encana Corporation}

23. "Emission reporting obligations have increased in the number and complexity over the last several years. This has prompted Enerplus’ to invest more time and funds in a comprehensive data management system. This action has enabled increased internal awareness of climate change regulations and risks as well as transparency in data management and calculations."
   \textit{Enerplus Corporation}

24. "The information collected during the CDP process provides Exxaro with valuable insight into the company’s overall performance regarding carbon emissions and thus allows for clear target setting in its energy strategy."
   \textit{Exxaro Resources Ltd}
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25.

“It is mandatory for those who emit more greenhouse gases to calculate to the applicable extent (specified emitters) their own greenhouse gas emissions and report them to the national government. In target offices for this emissions reporting system, we can expect enhanced work on reduction activities by revealing the energy efficiency inside the company, and an increase in sales of management systems for environmental performance data such as emissions and energy usage outside the company.”

*Fujitsu Ltd.*

26.

“We calculate our carbon footprint annually and therefore have visibility to our energy efficiency performance. We do recognize that there will be a need for greater accuracy and verification of performance. This will drive further improvement and, ultimately, contribute to a reduction in operating costs.”

*George Weston Limited*

27.

“HDFC Bank measures and manages Carbon footprint under the Indian regulation of publishing Annual Business Responsibility Report (ABRR). It also opens an opportunity to evaluate how the HDFC Bank can play a role in mitigating/reducing the footprint of the projects it finances. Creates opportunities to implement GHG reduction and Energy Efficiency projects at corporate offices, branches, and ATMs.”

*HDFC Bank Ltd*

28.

“Reporting of GHG emission will increase the investment of the monitoring system for emission sources which already improve the efficacy of hikma processes and decrees the energy consumed.”

*Hikma Pharmaceuticals*

29.
“Imperial Holdings’ Sustainability Management System, implemented due to various emissions reporting obligations, will in the future enable the setting of emissions reduction targets for each Imperial Holding’s Division, and if wanted/needed each Business Unit. This will result in more efficient operations and decreased carbon emissions.”

*Imperial Holdings*

30.

“Develop of environment management systems.”

*INDRA A*

31.

“The emissions reporting obligations could permit to review our processes, identify what can be optimized and potentially reduce the operational costs.”

*Ingenico*

32.

“Reporting obligations improve the quality of environmental data reporting which in turn assists IAG in managing environmental impacts and potential risks from the changing climate. A focus on reducing our footprint not only makes environmental sense, but also commercial sense since it will involve a reduction in consumption / increase in efficiency which will also lead to a reduction in operational costs.”

*Insurance Australia Group*

33.

“Emission reporting obligations help to drive up quality and quantity of data which enables more effective analysis of consumption and emissions in our hotels, leading to more effective and targeted solutions through IHG Green Engage that can further help them to reduce costs”

*Intercontinental Hotels Group*

34.
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“As a FTSE 100 company we are obliged to report on our GHG emissions. This is an opportunity to identify where efficiencies can be made and in many cases cost savings result.”

*Intertek Group*

35.

“Having been engaged with reporting our GHG emissions since 2012 we are in a strong position to respond to any and all requests from clients, stakeholders and other relevant parties.”

*Ipsos*

This only refers to reporting and not to monitoring. However, I assume that the strong position is mainly brought about by having done the monitoring, the results of which can then be reported. There remains, however, some ambiguity here.

36.

“The financial opportunities of a resilient supply chain directly as a result of emission reporting obligations range from consistent cost savings opportunities to an overall avoidance of system-wide disruptions.”

*Johnson & Johnson*

37.

“The regulatory obligation for emissions reporting presents opportunities for Kellogg. The current regulatory requirements for monitoring and reporting in the US provide a catalyst to better track and identify inefficient usage of energy.”

*Kellogg Company*

38.

“Reporting on our emissions since 2008 also made us capable to inventorize our emissions”

*Larsen & Toubro*
“With the enforcement of the reporting obligations, Lite-On will \textbf{benefit from the established GHG emission data} and find opportunities through identifying its main sources of emissions to reduce its carbon footprint, which can lead to reduction of operational costs in return.”

\textit{Lite-On Technology}

40.

“Emissions reporting obligations \textbf{result in careful analysis} of the sources of emissions and can result in development of technology to avoid emissions and/or to control them to avoid regulation.”

\textit{Merck & Co., Inc.}

41.

“Reporting of emissions \textbf{requires a complete understanding of all equipment that is a potential source of the emissions}. This action can help identify projects or process that may result in cost savings.”

\textit{Merck & Co., Inc.}

42.

“\textbf{Emission reporting obligations help to drive up quality and quantity of data}.”

\textit{Millennium & Copthorne Hotels}

43.

“\textbf{... enables more effective analysis} of consumption and emissions in our hotels, leading to more effective and targeted solutions that can further help to reduce costs.”

\textit{Millennium & Copthorne Hotels}

44.

“Reporting obligations could make Morgan’s customers \textbf{more aware of energy conservation opportunities} and thus more likely to invest in efficiency measures thus increasing demand for our products.”

\textit{Morgan Advanced Materials}
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45.

“Reporting obligations such as NGER in Australia, the CRC EE Scheme in the UK and the EPA issued Mandatory Reporting of Greenhouse Gases Rule in the US improve the quality of GHG emissions data available and reported and make it easier and less costly to assess climate change related risks in NAB’s lending portfolio.”

National Australia Bank

46.

“By implementing comprehensive emission and energy consumption reporting we are better able to monitor and minimise our energy consumption and thus cost”

Premier Oil

47.

“With the enforcement of the reporting obligations, Qisda will benefit from the established GHG emission data and find opportunities through identifying its main sources of emissions to reduce its carbon footprint, which can lead to reduction of operational costs in return.”

Qisda

48.

“Potential financial gains are estimated to amount to US$ 4,550 by identifying GHG reduction opportunities while fulfilling the reporting obligations; and thus further reduce our operational costs.”

Qisda

49.

“Emissions reporting obligations involve a deep work to identify emissions sources and data. This work leads to an increase the knowledge of the company processes and helps to identify improvement opportunities.”

R.E.E.
“Reporting and reductions requirements for company emissions could reduce energy costs at our facilities.”

*Regeneron Pharmaceuticals, Inc.*

51.

“This has helped to identify energy efficiency opportunities within the operations and reduce carbon emissions for the operations.”

*Royal Bafokeng Platinum Ltd*

52.

“Thanks to reporting, we are now able to identify our main GHG emission sources so that we can better act now to reduce both energy consumption and global impact.”

*Safran*

53.

“All external emissions reporting obligations represent an opportunity by providing an internal business driver within the organisation, firmly placing carbon reporting and climate change on the agenda. Examples include the UK CRC Energy Efficiency Scheme and the emission sources required under the Companies Act 2006 (Strategic Report and Directors’ Report) Regulations 2013 (mandatory reporting) This also includes voluntary reporting such as CDP and the Corporate Sustainability Report. These reports provide incentives to report and monitor carbon emissions in addition to setting annual or longer term reduction targets.”

*Smith & Nephew*

54.

“The reporting requirement leads to precisely measure GHG emissions.”

*Thales*

55.

“In part, provincial and federal reporting requirements in Canada (NPRI, CAPP Stewardship and RCE, D039, etc.), reporting and regulatory compliance
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obligations in Australia, the Netherlands and France has lead Vermilion to increase inventory, tracking and quantification of emission sources across our Business Units. The increase in tracking is allowing Vermilion’s Corporate Sustainability Team to assess opportunities across business units.”

Vermilion Energy Inc.

56.

“Mandates to report emissions and/or progress on reductions could help us to internally identify cost-reduction opportunities.”

Wal Mart de Mexico

57.

“Annual regulatory reporting such as National Greenhouse Energy Reporting (NGERS) as well as sustainability reporting has seen Wesfarmers develop better tools to manage environmental data, allowing the divisions to report more regularly and report back to internal and external stakeholders.”

Wesfarmers

58.

“The financial implications of reporting are currently unknown but can be qualified by improved efficiency and demonstrated ROI.”

WhiteWave Foods

Millennium & Copthorne Hotels, Merck, as well as Qisda were each coded twice.

A.2.3. Reporting obligations improve data within companies as response to regulatory risks

1.

“Group-wide sustainability strategy, supported by an £11 million investment programme, which includes: ... robust, consistent system for measuring and monitoring carbon emissions and performance against targets” Stagecoach Group

2. “The Group met the threshold for NGER reporting in FY 11. Systems and procedures for collecting, verifying and validating energy data
were developed at the time to address the compliance requirements under the NGER Act and are reviewed for continuous improvement on a regular basis.” *Super Retail Group*

3. “We **have implemented specific procedures for emission accounting** and we are improving in data quality every year.” *Orange*

4. ” **TBD, likely in the area of measurement and data management.**” *Pengrowth Energy Corporation*

5. “Reporting of GHG emissions is likely to become mandatory in South Africa in the near future (for companies that emit more than 100 00 TCO2e per annum). In line with this Pioneer Foods and its suppliers will have to **establish systems and processes to actively monitor, manage and reduce their emissions.**” *Pioneer Foods*

6. “The risk to RBPlat will be that in order to respond to this regulation a **comprehensive and rigorous emissions monitoring, reporting** and verification system will have to be implemented” *Royal Bafokeng Platinum Ltd*

7. “The IMO and other governmental bodies have been working for several years to develop a carbon mitigation strategy for the shipping industry. At this time, the method for reduction has not been narrowed down and still includes the possibility of mandating emission reporting. Operating and capital expenses could increase due to need for **more robust equipment** if this were enacted.” *Royal Caribbean Cruises Ltd*

8. “The process of **calculating the amount of emission** is generated by the emission reporting obligations.” *Sekisui Chemical Co., Ltd.*

9. “LG Chem **developed GHG Inventories to cope with climate-change regulations** and monitors energy consumption and GHG emissions every month through GEMS developed in 2009.” *LG Chem Ltd*

10. “Roberts is preparing for the changing regulations by **improving our data collection and reporting systems** and rolling out additional training on our Environmental Data Reporting Guideline to ensure that data that is reported is accurate.” *Murray & Roberts Holdings Limited*
A. Appendices

11. “we have developed a GHG Management System (to be implemented this year) to ensure a materially correct and fair representation of emissions required for yearly disclosure within the directors’ report.”  *Communisis Plc*

12. “... the company continuously improves its calculation methodology to more accurately reflect its business model, adjustments to the company’s carbon accounting were made as a result of joint the Midcontinent Independent System Operator (MISO).”  *Entergy Corporation*

A.2.4. Mentions of systems or technology as a response to reporting obligations

1.

“Also, thanks to our agreement with the International Civil Aviation Organisation (ICAO) to use their carbon calculator, we can provide a legitimate, neutral and global solution to report emissions in a worldwide, cross-industry standard way.”  *Amadeus IT Holding*

2.

“Our on-line database Enablon provides baseline information on travel and energy use across the countries in which we operate and we have a separate database to track energy saving opportunities on a monthly basis.”  *Australia and New Zealand Banking Group*

3.

“To manage this opportunity we utilize a corporate-wide web-based sustainability data collection tool. We use this tool to collect, amongst other things, data relating to energy usage/carbon footprint.”  *Avery Dennison Corporation*

4.

“Management is completed by internal staff and third-party consultants with the use of developed software.”  *Bonavista Energy Corporation*
5. “The data we use in reporting on the CRC is extracted from our **Corporate Environmental Reporting tool**.”
   *British American Tobacco*

6. “We are migrating our GHG data to a **new enterprise-wide software system** that collects all of Chevron’s environmental data, which will help us realize efficiencies and improve data quality.”
   *Chevron Corporation*

7. “Since 2013 Chevron is again upgrading its **GHG management system using Essential Suite**. The cost of this upgrade is projected to exceed $2 million of direct expense.”
   *Chevron Corporation*

8. “The Group **collects and stores its GHG data within a global third party data service provider**. Cost for the collection, collation and reporting of data is between AU$100,000 and AU$120,000.”
   *Commonwealth Bank of Australia*

9. ” In 2012, **320 million KRW was used to build the greenhouse gas inventory system**. from 2014 an additional cost of 90 million KRW will be used for the enhancement of the system.”
   *Daewoo E&C*

10. “To efficiently monetize the benefits of GHG reduction and renewable energy projects, we have created a process to capture every invoice for our energy and fuel purchases & track the data down to the site level. We have used these data to calculate our carbon inventory and intensities for our CDP responses, and we
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intend to submit current and historical carbon data in the U.S. to the Climate Registry this year.”

*Dean Foods Company*

11.

“DEXUS has incurred costs of $300,000 per annum. This is made up of internal and external resources, **upgrades to software** that stores and reports data and annual licence fees.”

*Dexus Property Group*

12.

“The costs associated with these efforts are the FTE costs associated with the 18 dedicated Sustainability and EHS personnel and those associated with our **software solutions**.”

*Dr Pepper Snapple Group Inc*

13.

“Constantly improving and updating on the DSV emission **calculating platform** [sic!]. Collecting specific data and calculating customer specific emission reports is a huge and time consuming tasks in the transport sector. In DSV quite amount of total resources are spent each year on data collecting, method improvement and calculation.”

*DSV A/S*

14.

“The direct costs related to compliance with EPA’s GHG reporting rule cannot be quantified at this time but include personnel to manage the fugitive leak testing, data management and reporting obligations of the rule; **equipment costs**; and costs associated with maintaining a **data information system**.”

*DTE Energy Company*

15.

“Emission reporting obligations could increase the demand for our **MRV system which controls the GHG fleet’s emission**.”

*Ecofrotas*
16. “Again, we will continue to utilize our internal management systems (i.e. Credit360) and processes to manage these risks as well.”  
   Eli Lilly & Co.

17. “To fully maximise this opportunity Emira is continuously improving the accuracy of its non-financial data through the use of a utility management company and a data management program in which the carbon footprint data is collected and reported on a quarterly basis.”  
   Emira Property Fund

18. “Improvements have been made to the CO2 Estimation dashboard on Centralized and Analytics. Updates include: aligning the emissions cofactors to the most recent 2014 GHG Protocol data, new metrics in which to normalize CO2 emissions in relation to our customers’ supply chain, and a refreshed look to the overall feel of the dashboard.”  
   Expeditors International of Washington

19. “In target offices for this emissions reporting system, we can expect enhanced work on reduction activities by revealing the energy efficiency inside the company, and an increase in sales of management systems for environmental performance data such as emissions and energy usage outside the company.”  
   Fujitsu Ltd.

20. “In Fujitsu group, for improving environmental management the environmental management dashboard” is built and taken advantage.”  
   Fujitsu Ltd.

21.
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“Every challenge presents an opportunity, mandatory regulations for emission reporting will generate new demands for automated emission reporting tools.”

_HCL Technologies_

22.

“software”

_Health Care REIT, Inc._

23.

“The costs for Holcim to operates these tools and systems is up to 100 kCHF per year.”

_Holcim Ltd_

24.

“We have been calculating GHG emissions in _Hyatt EcoTrack_ since 2009 in accordance with the GHG Protocol and hired PwC to validate our methodology.”

_Hyatt Hotels_

25.

“Increasing demands for CO₂ reductions has increased the opportunity for energy and sustainability services. Particularly Energy Statements, _SAP Assessments_ and SBEM assessments”

_Hyder Consulting (UK) Ltd_

26.

“The annual license and support fee for the _sustainability management system_, which is budgeted for, is roughly R1.2million.”

_Imperial Holdings_

27.

“_IHG Green Engage_ is our online sustainability tool for maximising the opportunities associated with climate change/carbon regulation.”

_Intercontinental Hotels Group_
“IBM’s suite of software offering including Maximo, Tivoli, Tririga Real Estate **Environmental and Sustainability Impact Management offers IT based software** to inventory, assess and manage energy and asset / material utilization and provides a platform that entities can use to gather data, manage assets, reduce energy use and report energy use or GHG emissions.”

*International Business Machines (IBM)*

“Costs are linked to the investment in a specific software, data collection (dedicated **software**).”

*JCDecaux SA.*

“Between $0 and $100 million USD, which we estimate based on an estimated increase in the sales of our **energy and GHG emissions management system**.”

*Johnson Controls*

“By anticipating the carbon reporting obligations, Kering strengthened its **carbon reporting tool**.”

*Kering*

“Cost of management would include human resources and time for regular monitoring of resource consumption and the **relevant systems deployed to manage the databases**.”

*Mahindra & Mahindra Financial Services*

“The company has implemented an **enterprise data management platform** and developed a systematic process for collecting, auditing, and reporting its **emissions data**.”

*News Corp*
A. Appendices

34. “These include the costs of ensuring that internal data management systems are robust, and adhere to the principles and requirements of the specific emissions reporting framework.”
   *Oceana*

35. “implementation of data systems reporting costs,”
   *Oceana*

36. “Oracle delivers several software solutions, such as the Environmental Accounting and Reporting (EA&R) tool, which help customers reduce their environmental impact and meet their emission reporting obligations. EA&R, which is an add-on module to Oracle’s Enterprise Resource Planning (ERP) system, enables end-users to easily track their greenhouse gas emissions and other environmental data …”
   *Oracle Corporation*

37. “Polarcus has designed and implemented a DNV GL certified emissions monitoring and reporting tool.”
   *Polarcus*

38. “We invested about KRW140 million in upgrading our existing GHG inventory management system SGIMS(Samsung C&T GHG Integrate Management System) to one that will respond to the domestic GHG Target Management System, and about KRW 20 million is expected to be necessary for system maintenance.”
   *Samsung C&T*

39.
“SAP anticipates that increasing regulation, such as emissions reporting, at the global, country, region, state, and local level will significantly increase the need for business process and reporting automation.”

*SAP AG*

40.

“To manage the greenhouse gas that is emitted from workplaces, the Company has established an **IT-based greenhouse inventory system**, through which the Company not only realized efficient energy management, but also has secured a basis on which to comply with the government’s Framework Act on Low Carbon Green Growth.”

*SK Chemicals*

41.

“To manage the greenhouse gas that is emitted from workplaces, SKT has established an **IT-based greenhouse inventory system**, through which was not only realized efficient energy management, but also has secured a basis on which to comply with the government’s Framework Act on Low Carbon Green Growth.”

*SK Telecom*

42.

“Both voluntary and mandatory reporting requirements have already presented opportunities for Sopra Steria, and it expects mandatory reporting to stimulate further, more consistent demand for its **sustainability data management and reporting solutions**.”

*Sopra Steria Group*

43.

“**Software** implementation and maintenance cost Associated costs for this in 2014 reached more than 1 million euros”

*Telefonica*

44.
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“Depending on the regulatory framework costs are considered to be 40,000 EUR to 60,000 EUR p.a. (estimations for IT systems)”

*Telekom Austria AG*

45.

“We have also developed a **sustainability impact tool** that will allow us to evaluate and prioritize projects affecting our footprint in terms of cost, savings, and environmental impact.”

*WhiteWave Foods*

46.

“Additionally, the implementation of our **data monitoring and tracking infrastructure** (approximately $150k over the next three years) is a cost that we feel will be offset by the savings found through energy management projects.”

*WhiteWave Foods*

47.

“We have invested in a more advanced **software-based management tool** to monitor data collection and performance on a day-to-day basis.”

*WPP Group*

48.

“To ensure best practice we implemented an **online platform** for data collection (Credit 360) in 2013, the initial outlay for the system was £55,000 and on top of this we will pay an annual subscription fee of £42,000.”

*Standard Life*

49.

“An overarching **company enterprise software system** has been developed, which non-financial data will feed into and provide automated carbon emissions accounting.”

*Sun International Ltd*

50.
“On the other hand, for improving data reliability and processing, some internal I.T. solutions were evaluated and adapted to Group Companies.”

T.ŞİŞE VE CAM FABRİKALARI A.Ş

51.

“Capability of data collection and management has improved so that we can deal with increase of data volume with accuracy. Data management tool is being considered as a next step.”

Takeda Pharmaceutical Company Limited

52.

“Creating a process to streamline GHG emissions through implementation of software solution.”

Tata Motors

53.

“Mandatory emissions reporting scheme would demand new resources such as auditing certificates, specialized software’s or human resources among others. The financial implications of a mandatory process would account 500,000 euros per year.”

Telefonica

54.

“Investment in a database to improve data recording, accuracy and reporting.”

Thomas Cook Group

55.

“The cost for carbon footprint calculation, verification, GHGs inventory and online system implementation is estimated to be around 1 million THB.”

True Corporation

56.
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“21st Century Fox has a robust program in place for collecting, measuring and analyzing its emissions data, and has developed a comprehensive repository of data with an enterprise data management software tool.”

Twenty-First Century Fox

57.

“2. Also in 2014, WM continued to invest in enhanced electronic data acquisition and management system for landfill gas monitoring and control.”

Waste Management, Inc.

58.

“Technologies and management systems are both needed to enable accurate emissions monitoring and reporting”

Weatherford International Ltd.

59.

“... online reporting tool in order to reduce the risk of non-compliance year on year”

Westpac Banking Corporation

60.

“Estimate up to £500,000 - costs of additional people and software resources.”

Wolseley plc

61.

“Requirement for energy reporting software and annual data verification £30,000.”

Workspace Group

62.

“As mandatory carbon reporting becomes more widespread across the countries we operate in, it is likely that the quality of our data will come under greater scrutiny, and may require investment in data capture technology.”

WPP Group

456
63. “The monitoring may require installation of **new monitoring equipment.**”
   
   ZORLU ENERJİ ELEKTRİK ÜRETİM A.Ş.

64. “During 2013 the group automated the data collection process by implementing a **software management tool**, making data collection and reporting more accurate.”
   
   Nampak Ltd

65. “a more bespoke **carbon data software package** to assist this maybe necessary”
   
   National Express Group Plc

66. “Some additional capital costs may also be required where **upgrades to metering and monitoring of energy usage** are needed.”
   
   News Corp

67. “Dedicated **software** and human resources”
   
   Nexans

68. “Financial implication of implementing a new tool in case of a methodology change of methodology : around 8,400 € for **purchasing a new tool** + 1,200 € /day for trainings”
   
   Nexity

69. “Cost associated to **Carbon Cube** :  • User license : 15,000 €/year  • Time managing the tool: 200h in 2014”
   
   Nexity
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70. “This cost is more expensive than previous years because Noble Energy implemented a new software system to collect and manage emissions and other data.”

    Noble Energy, Inc.

71. “Costs are likely to be borne relating to equipment and personnel for increased measurement, monitoring, data collation and reporting.”

    Nyrstar NV

72. “Old Mutual already collect and report all non-financial data that would need to be reported by this legislative change. The software used for managing our vast data resources costs approximately £50,000 per annum.”

    Old Mutual Group

73. “And by using its own EA&R software, Oracle is virtually eliminating the expense of manual accounting or purchase of a third party accounting solution.”

    Oracle Corporation

74. “Mandatory emissions reporting scheme will possibly demand new resources (auditing certificates, specialized software’s, human resources investments, among others).”

    Orange

75. “For example, we have been working on the implementation of a new reporting software since late 2011, which aim to provide us a more accurate reporting and an easier collection process.”

    Orange
A.2. Coded segments of CDP survey

76.

"Data is captured in an environmental Management Information System."

*PG&E Corporation*

77.

“We have purchased and installed data collection and reporting software for our energy and climate change data.”

*Philip Morris International*

78.

“Pitney Bowes has incurred additional costs by purchasing carbon accounting software and contracting a third party to support to comply with the requirement.”

*Pitney Bowes Inc.*

79.

“central management of software with localised data entry, coupled with assurance by a third party auditing company in the future. [sic!]”

*Renishaw*

80.

“This has also included the development of a carbon calculator which allows the monthly calculation of GHG emissions and energy usage”

*Royal Bafokeng Platinum Ltd*

81.

“In 2010 Royal BAM Group launched the Carbon Assessment Tool to help subcontractors assess their own carbon footprint. With this initiation Royal BAM Group tries to create more transparency in the supply chain.”

*Royal BAM Group nv*

82.
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“During 2013 an **Environmental Dashboard** was developed, which increases the efficiency in carbon reporting, and monitor progress.”

*Sanlam*

83.

“We have a **system** that allows us to track and keep nearly all environmental data, including that on energy.”

*Seiko Epson Corporation*

84.

“Specialist **software** to provide carbon accounting and management”

*Serco Group*

85.

“In 2010, Shinhan Financial Group established the **Green Management System** for energy and GHG data management and is constantly managing the GHG inventory.”

*Shinhan Financial Group*

86.

“And, S-OIL introduced”**GHG Mgt. IT System**” in 2011, investing 360 million KRW to create an inventory report to be submitted to the Government and readily monitor GHG data sourced from each facility & site.”

*S-Oil Corp*

87.

“We have **built the GHG emission inventory system** which measures the energy usage and GHG emission over the company.”

*Hansol Paper Co*

88.

“HDFC Bank has collaborated with external sustainability and carbon consultant for assistance in measuring the carbon footprint of the entire organisation with the help of **an IT tool**”

*HDFC Bank Ltd*
89.

"The costs associated with this proactive energy and carbon management and reporting include compensation for 7 regional engineers, 7 property directors, VP-Property Manager, SVP and VP of Information Management and the associated admin support full time staff, along with consultants and software valued at less than $150,000 annually."

*Health Care REIT, Inc.*

90.

“Hyundai E&C is using its very own **GHG/energy management system** to calculate the GHG emissions every year”

*Hyundai E&C*

91.

“We established the **MOBIS Greenhouse Gas Management System (MGMS)** in order to get a firm handle on our GHG emissions in 2011.”

*Hyundai Mobis Co Ltd*

92.

“Since the Company established **GHGs & Energy Management System**, it makes sure that the System keeps upgraded to be optimal for the target management scheme.”

*Hyundai Steel Co*

93.

“Establishment of corporate **Greenhouse Gas inventory system (IBK Carbon Management System)**: Initial cost is $500,000 and around $10,000 per year (maintenance)”

*Industrial Bank of Korea*
“Our primary tool for managing risks associated with climate change/carbon regulation is IHG Green Engage. It enables us to have accurate and auditable data for carbon reporting/trading purposes and ensures our hotels are prepared for tighter existing and ‘new build’ building standards.”

*Intercontinental Hotels Group*

95.

“In Intesa Sanpaolo expenses for the monitoring and reporting system amount to around 1 million euro per year.”

*Intesa Sanpaolo S.p.A*

96.

“Investec implemented a sustainability reporting system for non-financial data which is externally hosted, imports data from various sources, consolidates the information and calculates the organisation’s carbon footprint. This global solution covers operational impacts which include energy (electricity, gas and fuel), water, paper, waste and travel.”

*Investec Limited*

97.

“The ongoing annual software subscription fee for the sustainability reporting system amounts to £21,591”

*Investec Limited*

98.

“The costs associated with these actions are linked to hours spent implementing data collection and analysis, the investment in appropriate carbon measurement and management software and also data collection processes in certain countries which were added to the scope of JCDecaux reporting.”

*JCDecaux SA.*

99.

“ These obligations require more manpower and new systems to capture and report emissions and related data.”

*Johnson Controls*
100.

“KDHC spent 200 million won on operating the IT system, and 30 million won on third-party verification of GHG emissions in 2014.”

*Korea District Heating Corp.*

101.

“...GHG inventory implementation and server installation/operation”

*KT Corporation*

102.

“The so-called Kuehne + Nagel Global Transport Carbon Calculator has embedded a functionality that allows any transport activity in France to be tracked and reported according to French methods.”

*Kuehne + Nagel International AG*

103.

“We have managed a large portion of our risk from the burden of additional carbon reporting by developing a bespoke carbon reporting module to produce all reporting outputs from one central database, as required for each different set of parameters.”

*Land Securities*

104.

“LG Chem developed GHG Inventories to cope with climate-change regulations and monitors energy consumption and GHG emissions every month through GEMS developed in 2009. (Greenhouse gas and Energy Management System)”

*LG Chem Ltd*

105.

“The companies under the LG Group being regulated are operating a separate organization to respond to the regulations, and most are managing emissions by building an IT system.”

*LG*
A. Appendices

106.

“Future software development may be required and costs for this may exceed €200,000.”

L’Oréal

107.

“In future consideration will be given to acquire carbon management software to integrate carbon management reporting with current operating systems.”

Mediclinic International

108.

“For example the Australia National Greenhouse and Energy Reporting Act 2007 and software to manage such data costs in the order of $100,000 per annum”

Metcash

109.

“Business systems and administrative costs to track and report on emissions”

Mirvac Group

110.

“An environmental data management system has been embedded into standard business processes for many years accompanied by a regular audit and assurance program since 2010.”

Novion Property Group

111.

“In 2010, we completed enterprise-wide deployment of the Chevron GHG and Energy Reporting System (CGERS™).”

Chevron Corporation

112.

464
“... upgrades to software that stores and reports data and annual licence fees. Further improvements to the system will be made in the coming year as reporting and analysis of trends increases.”

City Developments Limited

113.

“We have specific budgets to initiate projects to meet these reduction targets, and we have data collection and reporting systems in place to support public reporting of our energy use and GHG emissions”

Clorox Company

114.

“We have developed a GHG Management System (to be implemented this year) to ensure a materially correct and fair representation of emissions required for yearly disclosure within the directors’ report.”

Communisis Plc

115.

“The method ConAgra Foods is using to manage the Emission Reporting Obligation risk is a proprietary, web-based reporting application invested in 2008 to ensure timely and accurate greenhouse gas emissions reporting. The web-based reporting application is also the method used for the 13 ConAgra Foods locations in calendar year 2012 that were required to report GHG emissions under the EPA’s Greenhouse Gas Mandatory Reporting Rule.”

ConAgra Foods, Inc.

116.

“In 2010, Cummins implemented an environmental data collection and tracking system that made the gathering and public reporting of performance data for Cummins locations easier and more accurate.”

Cummins Inc.

117.

“EHS management system is the methods for controlling CO2 emissions.”

SCREEN Holdings CO., Ltd.
A. Appendices

118.

“Danone has put in place a specific **CO2 reporting tool** that enables to measure emissions along the whole life cycle of the products in a very precise way (implemented in our ERP system SAP where applicable).”

*Danone*

119.

“Costs required to organize the reporting are mainly **IT tools** and increased FTE. For perspective, IT reshuffling cost is estimated at 2.5 M euros (carbon module construction).”

*Danone*

120.

“Costs include **licensing fees** and resources to manage the data collection and reporting process at both the member firm and DTTL-level are estimated in excess of $1,000,000 per year.”

*Deloitte Touche Tohmatsu Limited*

121.

“DEXUS has incurred costs of $300,000 per annum. This is made up of internal and external resources, upgrades to **software** that stores and reports data and annual licence fees, as well as fees for external data assurance.”

*Dexus Property Group*

122.

” Development of an **internal centralised reporting system/database** to allow more easy and accurate reporting of data”

*Distell Group Ltd*

123.

“We have purchased a **data reporting portal** that has the flexibility to produce reports in a number of formats which we hope will enable us to respond to different reporting requirements around the world without additional effort.”

*Domino Printing Sciences*
124.

".. Installing **IT system** (GEMS) fee: 0.3 billion KRW"
*Doosan Heavy Industries & Construction*

125.

“DPS manages direct and indirect risks that may significantly impact the achievement of the company’s objectives primarily through our Enterprise Risk Management (ERM) and **Environmental Management System (EMS)** processes, which include tracking our risks associated with energy use, costs, and the resulting carbon emissions.”
*Dr Pepper Snapple Group Inc*

126.

“we invest in **EHS regulatory auditing software**, and we invest in a partnership to calculate and house our greenhouse gas inventorying.”
*Dr Pepper Snapple Group Inc*

127.

“Methods we are using to manage this risk include utilizing a collection, analysis and **reporting system (Credit360)** to manage our internal reporting requirements for all environmental aspect data (including emissions).”
*Eli Lilly & Co.*

128.

“Plus, the ongoing maintenance cost of our **online air emissions reporting system** which is approximately $105K/annually.”
*Enbridge Inc.*

129.

“EU had approved in April 2014 a specific regulation about the “reporting of non-financial figures”. Although Erste Group had already collected environmental figures, this will require the implementation of **state-of-the-art software solutions** to be able to fulfil data requirement as efficient as possible.”
*Erste Group Bank AG*
A. Appendices

130.

“It is anticipated that the capital expenditure required to procure and implement an energy and carbon data performance management system will be ZAR5million.”

*Firstrand Limited*

131.

“To manage the environmental performance in the business sites, Global Environmental Database System (GEDS) has been deployed in Fujitsu.”

*Fujitsu Ltd.*

132.

“In fiscal year 2013, 3.1 billion yen was summed up as cost that leads the environmental management activity of all companies including maintenance and the operation of these environmental management systems”

*Fujitsu Ltd.*

133.

“GPT utilises internal analysts and a cloud-based environmental management database to capture, collate and maintain their emissions and energy data.”

*GPT Group*

134.

“Moreover, the Sustainability Management System (SMS) platform, that began operating in October 2014, will be used to collect the data needed for the emissions calculation.”

*Grupo Financiero Banorte SAB de CV*

135.

“Increased operational costs resulting from the need for systems and personnel to capture and report emissions data.”

*Afren*
“The cost of the required emission monitoring system has been 2,147,000 TL for Bozüyük, Kemalpaşa power plants due to installed GHG and exhaust gas monitoring systems.”

AKENERJİ ELEKTRİK ÜRETİM A.Ş.

“Ameren is required to spend additional money to gather this GHG data and file it with the appropriate agency. While not large it requires additional manpower and equipment to achieve compliance.”

Ameren Corporation

“The EPA reporting rule and 2014 Colorado regulations require capital equipment for monitoring and data collection.”

Anadarko Petroleum Corporation

“Apache is in the process of implementing a new enterprise-wide production data management system. Attached to this data management system is an environmental management information system software package to calculate and report emissions information from detailed field-level data inputs.”

Apache Corporation

“Licensing for our environmental reporting tool ‘Enablon’ costs around AUD$65,000 per year.”

Australia and New Zealand Banking Group

“Capital costs have also been invested in the implementation of smart meters and associated reporting technology.”

Australia and New Zealand Banking Group
A. Appendices

142.

“Baker Hughes made a capital investment of approximately $500K in emissions management software in 2011/2012.”

Baker Hughes Incorporated

143.

“Adding a country to the environmental Group reporting results in additional costs of round 50k€ which include wages of Group and local staff, IT costs (Enablon licenses & training) and statutory auditors verification.”

BNP Paribas

144.

“A total cost of ISO 14064 verification is 10,000$. Additionally it can cause the update and upgrade of the existing measurement and monitoring tools.”

BRİSA BRIDGESTONE SABANCI LASTİK SAN.VE TİC.A.Ş

145.

“carbon management software tool”

Britvic

146.

“The costs of managing risk associated with emission reporting obligations is related to the human resources required to manage data collection, measurement tools (e.g., metering devices and software), keep abreast of reporting rules through industry associations and use of our software for environmental tracking.”

Brown-Forman Corporation

147.

“To be able to adequately report it is necessary for an international company such as Bunzl to invest in software to collect, collate and analyse data.”

Bunzl plc

148.

470
“To mitigate the risk of misreporting associated with spreadsheet-based carbon accounting, Capgemini has implemented a dedicated carbon accounting system operated by a dedicated reporting team based out of Capgemini India.”

Cap Gemini

149.

“This solution supports the collection, management and reporting of all our environmental data. We industrialised our processes which had outgrown the original spreadsheet approach with its limited scalability and auditable processes in favour of a system capable of delivering financial grade environmental data suitable for the rigours of the CRC scheme and Grenelle II.”

Cap Gemini

150.

“We are at risk from the increasing emission reporting obligations which require significant manpower, education, systems, and other resources.”

CBRE Group, Inc.

A.2.5. Mention of need for human resource allocation to emissions monitoring and reporting implementation and process in response to reporting obligations

1.

“The costs of establishing a reporting framework and of actively taking part in contributing to an established reporting framework are estimated to be approximately 300,000 Euros.”

Alma Media Corporation

2.

“The costs associated with establishing the GHG inventory platform and having third party verification is more than US$ 16,660 annually.”

AU Optronics

3.
A. Appendices

This **process** is increasing our savings on an ongoing basis.

The annual costs include the **Group Environmental Manager** and external consultants for an annual cost of ZAR 50,000. This cost would occur for the next 5 years."

*Basil Read*

4.

“Across the Group it is estimated that at least **4 full-time equivalent staff members** are involved with sustainability related reporting.”

*Bidvest Group Ltd*

5.

“The **Sustainability Department** holds a professional, working together with experts, to closely monitor the evolution of national and international regulations related to emission reporting obligation. Around R$ 150,000 per year.”

*BRF S.A*

6.

“Our existing data and detailed understanding of product carbon footprints and other environmental performance indicators is maintained as part of our ongoing product and process improvement initiatives. ... Current cost of **managing the data** is CURRENCY$50k;”

*C&C GROUP PLC*

7.

“Increased **overhead costs** associated with more time dedicated to improving GHG reporting and any emissions reduction initiatives we implement.”

*Cairn Energy*

8.

\[^1\text{In the following sometimes currencies are indicated as CURRENCY as the original currency got lost in data transformation processes.}\]
A.2. Coded segments of CDP survey

“The cost of providing internal carbon accounting for Capgemini is approximately CURRENCY 250k p.a. ... The cost of the client carbon accounting services is dependent on the scope of services provided, but typically the service would be in the range of CURRENCY 100k to CURRENCY 400k p.a.”

Cap Gemini

9.

“The cost of management include the costs of maintaining and developing reporting processes as well as producing the annual report. This cost is budgeted annually and the estimated cost is 300 000-400 000 SEK per year.”

Castellum

10.

“No particular costs identified as relevant other than the present costs of collecting the data. Estimated cost of management: NOK 0”

Cermaq Group ASA

11.

“For example, in 2010 the cost of implementing Chevron’s GHG and Energy Reporting System (CGERS) was at least 2 million USD of direct expense. Together with the cost of training over 200 data reporters and the development of tools and processes, the total expense with staff time costs can be estimated to have been several million dollars.”

Chevron Corporation

12.

“To manage this opportunity the costs involve the collection and housing of emissions data, as well as the cost of having this data externally assured, ensuring the Government receives complete, transparent and accurate data. These costs equate to approximately AU$220,000 per year.”

Commonwealth Bank of Australia

13.

“The annual costs are related to the preparation of the emission inventory and third party audit.”

Companhia Energetica Minas Gerais - CEMIG

473
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14. “Also, to create more prompt responses, our company appointed one employee from the IT Management Team and two from the Corporate HSE Team as system operation staff and we increased the number of Corporate HSE staff. ... Furthermore, if our company is included among companies under the regulation, additional 10 million KRW will be needed for third-party verifications and further 12 million KRW for providing company-wide training to persons in charge (approximately 400 people).”

_Placeholder_ "Daewoo E&C"

15. “An obligation for DENTSPLY to report on its emissions may require added personnel and/or additional man-hours needed for analysis and executing action items.”

_DENTSPLY International Inc._

16. “DEXUS has incurred costs of $300,000 per annum. This is made up of internal and external resources, upgrades to software that stores and reports data and annual licence fees.”

_Dexus Property Group_

17. “We estimate the cost to maintain this data management system and to obtain annual external verification for this data to be about £200,000/yr.”

_Diageo Plc_

18. “Developing effective carbon management and measuring a footprint costs at about R200 000 per annum.”

_Discovery Holdings Ltd_
“The costs associated with these efforts are the **FTE costs** associated with the **18 dedicated Sustainability and EHS personnel** and those associated with our software solutions.”

*Dr Pepper Snapple Group Inc*

20.

“Constantly improving and updating on the DSV emission calculating platform. Collecting specific data and calculating customer specific emission reports is a huge and **time consuming tasks** in the transport sector. In DSV quite amount of total resources are spent each year on data collecting, method improvement and calculation.”

*DSV A/S*

21.

“The direct costs related to compliance with EPA’s GHG reporting rule cannot be quantified at this time but **include personnel to manage** the fugitive leak testing, **data management** and reporting obligations of the rule; equipment costs; and costs associated with **maintaining** a data information system.”

*DTE Energy Company*

22.

“However, in case this happens in the future, the Company is prepared to do so and it is **ahead of its competitors**, because, for years, it **has implemented** emissions inventories and history, GHG emission reduction actions, etc. ... R$70000.00 year.”

*Ecorodovias Infraestrutura e Logística S.A*

This implies that competitors would still need to go through a somewhat lengthy process. Here we need to take into account that such a statement would be socially desirable to make, in order to make one’s own company appear more competitive.

23.

“Our competitors who do not have GHG Inventory Management Systems in place will need to invest in developing a valid system for reporting obligations. This will require them to **invest both time** and funds into this system.”

*EKOTEN TEKST_L SANAY_ VE T_CARET A._*
A. Appendices

24.

“Personnel costs of one employee and verification of calculation. Estimation of the costs 100 000 EUR yearly.”

Elisa Oyj

25.

“The management costs are ZAR243,750.17. This is an annual cost with no expected end date.”

Emira Property Fund

26.

“Not including internal staff time, maintaining the emissions database and producing emission reports costs approximately $85,000 annually.”

Enerplus Corporation

27.

“In-house expertise and assessment tools represent 100 K CHF to 500 K CHF/year”

Givaudan SA

28.

“In addition to the ongoing efforts to reduce product life cycle climate impacts of our products, including energy efficiency improvements in the supply chain, transport and distribution, our operations, and our global garment collecting & recycling program, during 2012 H&M employed a full-time product life-cycle impact expert, in part to address this opportunity through a range of activities.”

H&M Hennes & Mauritz AB

Here we can already see overlap between responses to emissions reporting obligations and LCA.

29.
“The costs associated with this proactive energy and carbon management and reporting include compensation for 7 regional engineers, 7 property directors, VP- Property Manager, SVP and VP of Information Management and the associated admin support full time staff.”

*Health Care REIT, Inc.*

30.

“The resources for LCA calculations (working hours, data management systems and software) and reporting costs annually some 0.1 M CURRENCY.”

*Huhtamäki Oyj*

Here we can already see overlap between responses to emissions reporting obligations and LCA.

31.

“Current management methods aim to increase the impact of the opportunity through continued management and training of those operating the system.”

*Imperial Holdings*

32.

“To monitor its GHG emissions, the Group Quality and Environment Department realizes an assessment of the GHG emissions on the entire value chain of the Group (scopes 1, 2 and 3). This approach allows to identify some improvement axis.”

*Ingenico*

33.

“The cost of management associated with these activities is included in existing operational budgets (e.g. facility management staff and sustainability staff). Estimated to take 10% of their time, and hence 10% of total staff costs involved = $60,000”

*Insurance Australia Group*

34.
A. Appendices

“These activities are carried out by various departments of Intesa Sanpaolo, but we can assume that they involve an overall commitment of three FTE (full time equivalent) with an estimated gross cost of 45,000 Euro yearly each”

Intesa Sanpaolo S.p.A

35.

“The costs of Paper Profiles and carbon footprint calculations are annually some 0.1 million CURRENCY.”

Metsä Board

36.

“The cost of management is 0.5 million yen per year for operation and maintenance the committee.”

Murata Mfg. Co.

37.

“Costs for collecting and reporting GHG emissions data are included as part of the overall costs of managing the company’s sustainability program so cannot be attributed solely to addressing these regulatory requirements. However, the company does incur costs for the management, audit and reporting of this information that total less than $1M per year.”

News Corp

38.

“The cost associated is around CURRENCY 24,000 including work hours price for elaborate the GHG Emission Report and external verification cost.”

Obrascon Huarte Lain (OHL)

39.

“administration costs”

Oceana

40.

“and administrative and staff time costs”

Oriflame Cosmetics AB
41. “The costs associated with these monitoring actions could results in increased staffing costs but may create carbon trading opportunities.”
   *Pengrowth Energy Corporation*

42. “O4. Emissions reporting obligations involve a deep work to identify emissions sources and data.”
   *R.E.E.*

43. “- Human resources costs: 100000 Euros/year”
   *R.E.E.*

44. “Divisional overhead to capture, verify and document organisational structure and energy consumption”
   *Serco Group*

45. “Group Standard Operating Procedures have been developed for Carbon Management and Carbon Reporting cost absorbed into mainstream work”
   *Serco Group*

46. “Full time resource to support Mandatory Carbon Reporting in the Annual Directors Report with additional support in each Division at an annual cost of £100,000.”
   *Serco Group*

47. “The annual effort for sustainability reporting is estimated at 200 hours. Together with the cost of preparing the Company’s report to the CDP, costs are estimated to be in the order of $100K annually. Furthermore 2 FTE are dedicated to sustainability.”
   *Simon Property Group*
A. Appendices

48.

“- Emissions accounting process”
Telefonica

49.

“A carbon reporting manager had been employed to oversee and maintain the system.”
Transpacific Industries Group

50.

“management”
Twenty-First Century Fox

51.

“A dedicated System Administrator is used to manage the upload of all data, which includes electricity, natural gas, LPG, diesel and petrol usage across more than 90% of the business.”
Woolworths Limited

52.

“But, if these obligations came into effect in most of our key markets, WPP would need to hire up to three people (one in each region) to manage the process.”
WPP Group

53.

“Internal effort for emission reporting obligations is around 200 hours, from Board level to Legal, Finance and Operations.”
Scentre Group

54.

“Increased emission reporting obligations will lead to higher operational costs because of more onerous administrative requirements”
Just Eat

480
55.

“There are likely to be additional costs associated with collecting and reporting data. These are estimated to be less than £10,000.”

St. James Place

56.

“All of our reporting requirements have an implication in terms of resources (approximately 2 full time employees at a cost of around £100,000 per annum).”

Standard Life

57.

“Additional costs may be incurred if reporting is regulated and changes from the methodology currently being followed by Stantec are required. It is possible that these changes would result in substantive changes that could make data acquisition and calculation methodologies more onerous.”

Stantec Inc.

58.

“Key actions to minimise the risk of non-compliance with the NGER Act include full time employee resources allocated to meeting registration requirements, reporting requirements, record-keeping requirements and auditing requirements at a total cost of approximately $150,000 annually.”

Telstra Corporation

59.

“The employee(s) responsible for managing this is part of their annual fixed costs.”

The AES Corporation

60.

“R14,000 on internal staff dedicated to this activity.”

The Spar Group Ltd

61.
A. Appendices

“Member of staff to manage data reporting.”
*Thomas Cook Group*

62.

“The cost of management is very small compared to operational costs.
(Less than 1%)”
*TÜRKİYE HALK BANKASI A.Ş.*

63.

“Emission reporting obligations could impact our net income directly due
to increased costs related to recordkeeping, reporting, verification and
purchases of greenhouse gas compliance instruments.”
*Union Pacific Corporation*

64.

“Management of the mandatory emissions reporting quality program costs
approximately $50,000 per year.”
*United Technologies Corporation*

65.

“There are currently £5k in staff costs associated with time spent on this.”
*United Utilities*

66.

“Increased operational costs will be incurred at facilities subject to formal
emissions reporting obligations because unique monitoring, recordkeeping
and reporting programs must be developed and implemented for each
unique formal emissions reporting obligation.”
*Weatherford International Ltd.*

67.

“Key costs include FTE ...”
*Westpac Banking Corporation*

68.
“Estimate up to £500,000 - costs of additional people and software resources.”

Wolseley plc

69.

“Average management salary at April 2015 R369,253. Management means senior, middle and junior management & skilled staff lumped together”

Woolworths Holdings Ltd

70.

“However, if these obligations came into effect in the majority of our key markets, WPP would need to hire additional resources of up to three people (one in each major region) to manage the reporting process.”

WPP Group

71.

“The cost of management includes Emission Measurement Costs, which are 7,334.2 USD and Emission Verification of the Measurement by Environment & Urban Planning Directorate, which is 733,33 USD.”

YÜNSA YÜNLÜ SANAYİ VE TİCARET A.Ş.

72.

“The costs associated with the investment for establishing ISO 14064 reporting system for Zorlu Enerji facilities is difficult to disintegrate from the overall routine use of human resources, management, monitoring and implementation activities except for the verification costs.”

ZORLU ENERJİ ELEKTRİK ÜRETİM A.Ş.

73.

“... time spent by internal staff, contractors and contracted facilities managers on collating and reporting on data as well as external assurance fees.”

National Australia Bank

74.
A. Appendices

“Newfield spent approximately $500,000 to $1 million in **GHG monitoring, record keeping, and data management** in 2014.”

*Newfield Exploration Co*

75.

“$200,000/year for **employee** and contractor costs.”

*Newmont Mining Corporation*

76.

“Dedicated software and **human resources** Make sure the company have **internal competencies**”

*Nexans*

77.

“Cost associated to the GHG assessment: **800 hours** in 2014”

*Nexity*

78.

“The **VP of Environment** works with the **Director of Environment** to oversee the **team responsible** for emissions reporting obligations.”

*NRG Energy Inc*

79.

“There are approximately **2 full time employees** at the corporate level responsible for NRG’s annual emission inventory.”

*NRG Energy Inc*

80.

“There are also over **50 emissions managers** across the fleet that are responsible for entering emissions data directly to the EPA and complying with audits.”

*NRG Energy Inc*

81.
“Costs are likely to be borne relating to equipment and personnel for increased measurement, monitoring, data collation and reporting.”

_Nyrstar NV_

82.

“The cost of the development, roll out and training associated with the new Group SHE Reporting Guideline was R133 000. This also involved conducting a series of on-site SHE data reviews to ensure that environmental reporting to date is representative.”

_OMNIA HOLDINGS LTD_

83.

“Mandatory emissions reporting scheme will possibly demand new resources (auditing certificates, specialized software’s, human resources investments, among others).”

_Orange_

84.

“There would be financial implications associated to an increase in administrative and staff time costs derived from adapting to new reporting requirements. The costs have been estimated to be 4.000 – 30.000 euro.”

_Oriflame Cosmetics AB_

85.

“The total costs associated to the verification of our data, investments in energy audits, provision of consultancy services to support the sustainability team on the data gathering process and carbon footprint calculation, and administrative and staff time costs are approximately of 140.000 €.”

_Oriflame Cosmetics AB_

86.

“Origin has a dedicated Carbon Reporting team which manages this risk.”

_Origin Energy_
A. Appendices

87.

“The financial implications of increased emission reporting obligations are expected to be minimal and at maximum could include an additional full time employee.”

*Parker-Hannifin Corporation*

88.

“TBD, likely in the area of measurement and data management. ... The costs associated with these actions could result in increased staffing needs.”

*Pengrowth Energy Corporation*

89.

“The cost associated with administrating the annual data analysis, including personnel time and the expense of the external auditing firm, is approximately $120,000.”

*PepsiCo, Inc.*

90.

“Increased reporting requirements could mean a need to hire additional personnel for reporting purposes. The impact of this would be not more than R300k.”

*Pick 'n Pay Stores Ltd*

91.

“Qantas allocates approximately 1 full time equivalent (FTE) resource to manage the Group's emission reporting obligations.”

*Qantas Airways*

92.

“if not it will be the cost of one full time employee to complete all the necessary work, analysis and auditing of the data.”

*Renishaw*

93.
“The potential financial implications of increasing emission reporting obligations include increased operational costs associated with increased greenhouse and energy monitoring and reporting processes, improvements in data quality to meet compliance, and increased verification and assurance processes.”

_**Rio Tinto**_

94.

“the cost of **revising and managing** the GHG inventory management system (about KRW180 million),”

_**Samsung C&T**_

95.

“**Staff time** in gathering GHG data (up to 2 FTEs) as well as auditor costs for external assurance.”

_**Santos**_

96.

“There is **internal human resource** costs associated with managing the climate risk.”

_**Sasol Limited**_

97.

“Furthermore, **dedicated and trained resources** are in place to deal with reporting obligations at each facility.”

_**Senior Plc**_

98.

“**Divisional overhead** to capture, verify and document organisational structure and energy consumption

Standard Operating Procedures have been developed for **Carbon Management and Carbon Reporting cost absorbed into mainstream work**”

_**Serco Group**_

99.
A. Appendices

“Serco have invested in full time resource to support CRC, Mandatory Carbon Reporting in the Annual Directors Report, and the CDP, with additional support in each Division at an annual cost of £100,000”

Serco Group

100.

“Internal resourcing to meet reporting obligations.”

Singtel

101.

“Emissions reporting and verification obligations ... require companies to allocate human and financial resources to data gathering, measuring, reporting, and the audit process.”

Sopra Steria Group

102.

“Costs associated with all regulatory risks: The costs associated with this proactive energy and carbon management and reporting include compensation for 7 regional engineers, 7 property directors, VP- Property Manager, SVP and VP of Information Management and the associated admin support full time staff, along with consultants and software valued at less than $150,000 annually.”

Health Care REIT, Inc.

103.

“Management time at each site plus consultant’s time.”

Hill & Smith Holdings

104.

“Increased administration required to track and report greenhouse gas emissions.”

Hormel Foods

105.
A.2. Coded segments of CDP survey

“Costs will be incurred in terms of **in-house management time** and external resource as appropriate.”

*IMI plc*

106.

“Company specific: This has the potential to increase **administrative costs** for Imperial Holdings due to the need for **additional staff and additional time** required for reporting.”

*Imperial Holdings*

107.

“Reporting requirements could imply the need of better data collection processes, which could mean higher operational costs on **developing a proper data collection** according to new requirements.”

*Imperial Tobacco Group*

108.

“This does not include **management time and costs** in understanding the requirements, involvement in consultations, and ensuring appropriate representation of the data in the Annual Report and Accounts.”

*Intercontinental Hotels Group*

109.

“These activities are carried out by various departments of Intesa Sanpaolo, we can assume that they involve an overall commitment of **three FTE (full time equivalent)** with an estimated gross cost of 45,000 Euro yearly each.”

*Intesa Sanpaolo S.p.A*

110.

“The main costs are approximately 2 million TWD/yr, which include **personnel cost.”*

*Inventec Co Ltd*

111.
A. Appendices

“devoting dedicated resources to reporting”

IOOF Holdings

112.

“We estimate the internal cost is approximately 1/2 a FTE (due to the global scope), and therefore about £20,000.”

ISG plc

113.

“The costs associated with these actions are linked to hours spent implementing data collection and analysis, the investment in appropriate carbon measurement and management software and also data collection processes in certain countries which were added to the scope of JCDecaux reporting.”

JCDecaux SA.

114.

“The”emission reporting obligations” ... require more manpower and new systems to capture and report emissions and related data.”

Johnson Controls

115.

“Time put into reporting greenhouse gas emissions to government bodies is split between employees and consultants for a cost of approximately $450,000 in 2013.”

Keyera Corp.

116.

“... We will be required to measure the emissions from our overseas operations, requiring us to expend additional management time in collecting and collating this data.”

Kier Group

117.
“It is imperative that our employees working at our environmental team understand the risks that are caused by regulatory issues. To ensure that KT minimizes such risks, we have hired employees that are regarded to be familiar to environmental regulations.”

KT Corporation

118.

“Inherent risk: to comply with this new and existing legislation, Kuehne + Nagel need to invest time and effort in greenhouse gas (GHG) accounting and reporting.”

Kuehne + Nagel International AG

119.

“Cost are being allocated annually (for project management, information technology (IT) man days and travel expenses purposes)”

Kuehne + Nagel International AG

120.

“Inclusion of additional relevant employees to handle the concerned activities”

Lawkim Motors Group division - Godrej and Boyce Mfg. Co. Ltd

121.

“While there are not variable costs, there are labor costs currently associated with our employees’ time to manage this risk.”

Layne Christensen Company

122.

“... investment costs to reduce greenhouse gas are likely to rise, such as costs related to the development of a greenhouse gas inventory management system and expenses related to third party verification.”

LG Life Sciences

123.
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“The cost of establishing the GHG inventory and passing third party verification is more than US$20666 yearly.”

_Lite-On Technology_

124.

“I 2014, the cost of additional time spent on data reporting is estimated at £20,000.”

_Lloyds Banking Group_

125.

“There would be increased costs for our team that is responsible for emissions data reporting, both in terms of the time required to familiarise themselves with the terms of the reporting obligations, and in executing the obligations before the required deadline.”

_L’Oréal_

126.

“Compliance at country level, monitoring at Group level. Project management of developments and general management. ... $500’000 Annually”

_Lundin Petroleum_

127.

“$60,000- Estimated cost of personnel resourcing to manage and fulfill reporting obligations.”

_Manitoba Telecom Services_

128.

“Any additional reporting requirements could present reputational risks and may result in additional financial and administrative costs”

_McBride plc_

129.

“Added cost is associated with additional time to collect and report data. It is not significant when compared to the total cost of ensuring environmental compliance around the world.”

_Merck & Co., Inc._
130.

“Increased reporting requirements from authorities may generate additional administrative costs due to the expansion of the required data collection systems.”

Merck KGaA

131.

“A dedicated manager, external audit, subscription to carbon and environmental accounting software.”

Metcash

132.

“Business systems and administrative costs to track and report on emissions”

Mirvac Group

133.

“The costs are minimal and they are mainly related to employing staff to complete the reporting requirements.”

Modern Times Group MTG AB

134.

“#3 Establishment of clear processes and procedures as part of the Group’s management systems to ensure that appropriate management controls are put in place.”

Morgan Sindall Group plc

135.

“Upstream emission reporting obligations are managed by one full time employee with estimated staff costs of around CAD$115k (£65k).”

Centrica

136.
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“Annual cost of maintaining a data management system, collecting data, and doing audits of the assets.”

Novion Property Group

137.

“The costs to manage the NGERS reporting process includes ... plus the internal costs to manage the reporting process which is equivalent to an FTE or (~$100,000)”

Charter Hall Group

138.

“S) was at least 2 million USD of direct expense. Together with the cost of training over 200 data reporters and the development of tools and processes, the total expense with staff time costs can be estimated to have been several million dollars.”

Chevron Corporation

139.

“The cost of management is only for human capital resources needed.”

China Steel

140.

“i) internal and external resources,”

City Developments Limited

141.

“Cost of management has not been calculated but it will likely occur on an annual basis.”

Coach, Inc.

142.

“Dedicated and trained resources are in place to deal with reporting obligations in high risk regions such as Australia.”

Cobham
143.

“... cost of reporting is approximately 0.25 FTE employee (equating to approx. £10,000).”
Communisis Plc

144.

“... increased reporting requirements may require our small company to hire additional staffing to comply thus increasing operational costs”
Compatico

145.

“The incremental expense associated with reporting our GHG emissions to the US EPA for these locations is nominal, requiring only the time and effort of corporate resources to enter information into EPA’s e-GGRT system (estimate at less than $5,000).”
ConAgra Foods, Inc.

146.

“While there were no direct financial costs associated with creation of these plans, significant management time and human resources were allocated to ensure the successful completion of Crown’s regulatory obligations.”
Crown Resorts

147.

“The cost of the environmental data collection and tracking system including the human resources to support it is less than $500,000 per year.”
Cummins Inc.

148.

“Costs required to organize the reporting are mainly IT tools and increased FTE.”
Danone

149.
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“Costs include reporting administrative burden.”
Deere & Company

150.

“Costs include licensing fees and resources to manage the data collection and reporting process at both the member firm and DTTL-level are estimated in excess of $1,000,000 per year.”
Deloitte Touche Tohmatsu Limited

151.

“£500,000-£1m as 0.5% of operational expenditure annually due to the costs associated with measuring, managing and disclosing performance”
Dentsu Aegis Network

152.

“£50,000 as an investment in local and global capacity to accurately measure, manager and report GHG emissions”
Dentsu Aegis Network

153.

“The cost of management is absorbed as part of the Sustainability Team’s role.”
Derwent London

154.

“Development and maintenance of companywide emissions inventory system.”
Devon Energy Corporation

155.

“DEXUS has managed and continues to manage specific resources to deliver the reporting requirements including the appointment of external consultants and internal analysts to manage the collection of and maintenance of emissions data.”
Dexus Property Group

496
156.

“€ 100,000 is the estimation of the total management costs (for the next 3-6 years) to collect the information. This includes the involvement of both internal resources and external assistance.”

Diasorin SpA

157.

"Additional R2m/a in salaries for additional resources to undertake the required reporting.

Development of an internal centralised reporting system/database to allow more easy and accurate reporting of data”

Distell Group Ltd

158.

“Reporting system £30,000 extra staff time in producing reports could cost no more than £50,000 a year”

Domino Printing Sciences

159.

“Estimated costs of these actions: R$ 8,013,939.13 Costs associated to risk management actions include the inventory’s development and external assurance;”

Duratex S/A

160.

“Estimated annual cost of management is less than 1% of the Group’s operating costs.”

Electrocomponents

161.

“It will vary according to the control to be required in inventories and the staff needed to maintain it and, depending on the request, checks it”

EMFLORA
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162.

“Increased reporting obligations may require the acquisition of additional full time employees (FTE) and an upgrade to our existing Emissions Management System.”

*Enbridge Inc.*

163.

“The cost of managing our current air emission reporting obligations include three full time employees (FTE) at the Business Units is approximately $300K/annually.”

*Enbridge Inc.*

164.

“However in the longer-term (5 yrs.) additional reporting requirements may result in the need for an additional FTE, $75k/year.”

*Entergy Corporation*

165.

“Monitoring, measuring, recording and reporting this data requires dedicated staff resources.”

*Ernst & Young LLP UK*

166.

“Minimal other than internal staffing time and assurance auditing cost by a third party.”

*Fletcher Building*

167.

“Operational organization cost KRW 234,000,000 caused by additional work such as reporting of greenhouse gas emissions, negotiating objectives and reduction activities is expected”

*GS Engineering & Construction*

168.
“Increased operational costs resulting from the need for systems and personnel to capture and report emissions data.”

_Afren_

169.

“Management costs include assurance costs and labour.”

_AGL Energy_

170.

“... need to report metrics such as carbon emissions and fuel consumption ... has proved challenging to coordinate initially, the process will become more efficient, the more emissions reporting becomes routine.”

_Allied Irish Banks plc_

171.

“The costs include the development of emissions reporting scheme: tracking and analyzing the emissions of Alma Media’s operations as well as developing the knowledge and tools to communicate these.”

_Alma Media Corporation_

172.

“Emission reporting obligations may have a significant financial implication for two reasons: - human resource: answering these obligations is time-consuming and skill-specific.”

_Altén_

173.

“Data is collected at all sites globally and is submitted to the Global EHS manager by regional EHS managers.”

_Amdocs Ltd_

174.

“Ameren is required to spend additional money to gather this GHG data and file it with the appropriate agency. While not large it requires additional manpower and equipment to achieve compliance.”

_Ameren Corporation_
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175.

“AEP utilizes information management systems to collect CO₂ data and **internal staff** to appropriately populate required reports.”


176.

“The **ELC** is responsible for working with relevant areas of the business to complete the necessary reporting obligations. Once complete, these reports are reviewed by the Managing Director of AMP Capital representing the AMP Group Leadership Team. **Management time.**”

*AMP*

177.

“In addition to the upfront **internal costs**, the company has spent more than $200,000 in 2014 to prepare for and report to the GHGRP.”

*Anadarko Petroleum Corporation*

178.

“Reporting requires **significant management time**. GHG reporting is part of the suite of sustainability reporting carried out by the company and it is not possible to quantify it separately.”

*AngloGold Ashanti*

179.

“During the reporting period, Aquarius conducted **internal data assurance** in order to improve reporting of GHG-related data and to and ensure that data reported was accurate and representative. The cost of the internal assurance project was R200,000.”

*Aquarius Platinum*

180.

“Estimated order of **magnitude cost of management** is €100,000/year.”

*Arcadis*
181.

“Additional reporting, disclosure or energy management legislation in a new Country would add management and possibly external costs.”

*ARM Holdings*

182.

“ABF has liaised with operating companies affected and put in place a project management team who ensure the relevant data is collated in the correct format, appointed expert assessors in line with UK ESOS regulation to QA data and processes and to ensure full compliance.”

*Associated British Foods*

183.

“Aurizon has appointed a dedicated full time position responsible for compliance with the NGER Act 2007.”

*Aurizon Holdings*

184.

“Financial implications are associated with the commitment of staff time and conducting external verification which are approximately $350K/year.”

*Baker Hughes Incorporated*

185.

“To ensure accuracy and assurance of the reported data it will require outlay in human resource, training and/or consultation costs.”

*Basil Read*

186.

“The costs of management are included in the work of the two employees which are responsible for sustainability.”

*Basler Kantonalbank*
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“Our operating businesses have **specific roles dedicated to reporting**. Our reporting functions are responsible for the systems and procedures associated with the **capture and recording** of data and compliance.”

*BHP Billiton*

188.

“The costs of managing risk associated with emission reporting obligations is related to the **human resources** required to manage data collection, measurement tools (e.g., metering devices and software), keep abreast of reporting rules through industry associations and use of our software for environmental tracking.”

*Brown-Forman Corporation*

189.

“The financial implications of the emissions reporting legislation risk are not significant for Buzzi’s business and are mainly related to **staffing** on disclosure activities.”

*Buzzi Unicem*

190.

**Overhead costs** associated with the **amount of time** needed to **gather** and report data.”

*Cairn Energy*

191.

“We are at risk from the increasing emission reporting obligations which require **significant manpower, education**, systems, and other resources.”

*CBRE Group, Inc.*

192.

“Serco have invested in **full time resource** to support CRC, Mandatory Carbon Reporting in the Annual Directors Report, and the CDP, with additional support in each Division at an annual cost of £100,000”

*Serco Group*
“These activities are carried out by various departments of Intesa Sanpaolo, we can assume that they involve an overall commitment of three FTE (full time equivalent) with an estimated gross cost of 45,000 Euro yearly each.”

Intesa Sanpaolo S.p.A

“It is imperative that our employees working at our environmental team understand the risks that are caused by regulatory issues. To ensure that kt minimizes such risks, we have hired employees that are regarded to be familiar to environmental regulations.”

KT Corporation

“A dedicated manager, external audit, subscription to carbon and environmental accounting software.”

Metcash

“Upstream emission reporting obligations are managed by one full time employee with estimated staff costs of around CAD$115k (£65k).”

Centrica

“Increased reporting obligations may require the acquisition of additional full time employees (FTE) and an upgrade to our existing Emissions Management System. A higher Greenhouse Gas Warming Potential for methane may lead to higher expected compliance costs if Ontario moves to a cap and trade system. At a minimum, one additional FTE would be required at a cost of approximately $100K annually.”

Enbridge Inc.
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“The cost of managing our current air emission reporting obligations include three full time employees (FTE) at the Business Units is approximately $300K/annually.”

Enbridge Inc.

199.

“However in the longer-term (5 yrs.) additional reporting requirements may result in the need for an additional FTE, $75k/year.”

Entergy Corporation

200.

“Aurizon has appointed a dedicated full time position responsible for compliance with the NGER Act 2007.”

Aurizon Holdings

A.3. More detailed results on the costliness of EPDs

Amongst people interviewed by the team assembling the 1997 EEA Life Cycle Assessment Guide, “there was a general consensus ... that the LCA process needs to be speeded up if it is to be properly integrated into business design and strategy” (European Environment Agency 1997). This points to factors speeding up the LCA process as potentially crucial to lowering its costs. The guide claims that

“Data collection is often the most work intensive part of a life cycle assessment, especially if site specific data are required from all the single processes in the life cycle.” (European Environment Agency 1997, 59)

Anderson et al. (2006) note that

“It is important that the ... client should not underestimate the time that they may need to invest to provide [quality LCI production data].”

Construction product testing institute ift Rosenheim states that
"A specific EPD is considerably more costly and time-consuming for manufacturers [than an average EPD for a product], because it involves gathering and evaluating extensive data.” (ift Rosenheim, n.d.)

Joep Meijer suggested that EPDs could serve as a market barrier for smaller companies, which points to their costliness. He suggests that the EPD process is expensive, as well as time and resource intensive.\(^2\) He estimates the costs for an industrywide EPD that is developed for the first time to be between EUR 50,000 and 150,000. Once an industry association has developed an EPD spreadsheet and there are only a few parameters that need to be modified in order to represent the plant specific product, it can cost less than EUR 1,000. For a single producer it would cost about EUR 15,000 to develop a new EPD and EUR 5,000 for review and certification.\(^3\)

Danny Püschel, who coordinates the department responsible for EPDs in a German company that produces LCAs for buildings and building materials, asserts that EPDs are not cheap. He estimates costs of about EUR 12-15,000 per EPD, including software, travels and learning about LCA.

A representative of the US Portland Cement Association (PCA), the major cement manufacturing association in North America, stated that the process of collecting, compiling and validating the information for their standardised EPC creation process costs time and money.\(^4\).

A DGNB representative also said the costs would be significant.\(^5\)

### A.4. Sources for claims about materials’ sustainability benefits

<table>
<thead>
<tr>
<th>Material</th>
<th>Sustainability quality claim</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel - virgin</td>
<td>recyclable</td>
<td>Eurofer (2013), p. 31; ArcelorMittal (n.d.); Wintermann (2013)</td>
</tr>
</tbody>
</table>

\(^2\)Interview in 2017.
\(^3\)Email exchange with Joep Meijer in November 2018.
\(^4\)Interview with PCA in 2017.
\(^5\)Interview with DGNB in 2016.
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<td>(n.d.)</td>
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<td>(2018b); ArcelorMittal</td>
<td>(n.d.)</td>
</tr>
<tr>
<td>Wood for construction carbon</td>
<td>Wood for Good (2012); Nabuurs et al. (2015), p. 3; American Forest Foundation (2015); Deutscher Holzwirtschaftsrat (n.d.)</td>
<td></td>
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<tr>
<td>Wood for construction natural</td>
<td>Swedish Wood (n.d.)</td>
<td></td>
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<tr>
<td>Wood for construction recyclable (into biofuels)</td>
<td>Swedish Wood (n.d.)</td>
<td></td>
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<tr>
<td>Wood for construction re-use</td>
<td>Swedish Wood (n.d.)</td>
<td></td>
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<tr>
<td>Wood for construction renewable</td>
<td>Think Wood (2018)</td>
<td></td>
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<tr>
<td>Concrete recycled</td>
<td>The Concrete Centre (n.d.)</td>
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<tr>
<td>Concrete recyclable</td>
<td>The Concrete Centre (n.d.)</td>
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<tr>
<td>Concrete carbon sequestration</td>
<td>Xi et al. (2016); Portland Cement Association (2018)</td>
<td></td>
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<td>Concrete carbon sequestration</td>
<td>Lord (2018)</td>
<td></td>
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<tr>
<td>Wood for heating carbon neutral</td>
<td>P. Smith et al. (2014), pp. 829–832; Deutscher Energieholz- und Pelletverband (2016)</td>
<td></td>
</tr>
<tr>
<td>Wood for heating renewable</td>
<td>FAO (2017)</td>
<td></td>
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<tr>
<td>Wood for heating natural</td>
<td>Blackmore (2014)</td>
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A.5. Background on building materials

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<td>reuse</td>
<td>Brick Development Association (2014)</td>
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<tr>
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</tr>
<tr>
<td>Hemp</td>
<td>carbon sequestration</td>
<td>Lawrence (2014); UK Hemp Association (2018)</td>
</tr>
<tr>
<td>Hemp</td>
<td>natural</td>
<td>UK Hempcrete (2018); UK Hemp Association (2018)</td>
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<tr>
<td>Hemp</td>
<td>renewable</td>
<td>N. Smith (2014)</td>
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<tr>
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<tr>
<td>Straw</td>
<td>natural</td>
<td>Straw Bale Central (2012)</td>
</tr>
<tr>
<td>Straw</td>
<td>renewable</td>
<td>Sutton, Black, and Walker (2011)</td>
</tr>
</tbody>
</table>

A.5. Background on building materials

The following provides background information on some of the major building materials important for this study. Process emissions are an important aspect of the carbon intensity of building materials production and they are an important factor with regard to the possibilities for decarbonising production practices with currently available technologies. The emissions profiles and material qualities of building materials such as cement, steel, timber and clay vary considerably and there are important interactions between the use of these materials at the level of buildings.

A.5.1. The role of process emissions

In the cases of clinker and steel, an important share of emissions are process emissions from the chemical reactions involved in creating the materials in question. The process emissions are not caused by energy consumption but by the chemical reactions that lead to the creation of new materials (Neuhoff et al. 2014; Hicks, Caldarone, and Bescher 2015; Bringezu et al. 2015). Increases in
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energy efficiency or the roll-out of renewable energy are not going to contribute to the mitigation of these emissions.  

A.5.2. Materials

A.5.2.1. Steel

Iron and steel production are responsible for about 6% of global GHG emissions (Carbon Trust 2011). Steel is the dominant metal used in the construction industry (Green Construction Board 2013, 63). More than half of the world’s steel is used in construction, with the single largest area of application being concrete rebar. Other major uses are structural sections and sheet (Allwood and Cullen 2011, 35ff.).

There are two main routes for steel production: First, basic oxygen furnaces (BOF), which produce virgin steel by subjecting molten pig iron and steel scrap to blasts of supersonic oxygen. By the late twentieth century BOFs accounted for about 70% of world steel production. The second major steel production route is based on recycling scrap metal via electric arc furnaces (EAF). In the USA EAFs account for 61% of steel production, in the EU for 41% and for about 10% in China (Smil 2014, 58f.).

Steel producers emphasise the recyclability of their material (see e.g. Eurofer 2013, 31). However, about 60% of the steel, which has accumulated over more than a hundred years, is locked up in structures, with about 10% stored in the form of vehicles (Smil 2014, 60). Bar demolition activity, and the often necessary costly separation of rebar from concrete, the steel locked into the built environment remains unavailable for recycling.

The steel industry uses the argument of infinite recyclability of steel while downplaying the fact that this recycling often involves downcycling as the steel quality suffers due to the presence of tramp elements. For example ArcelorMittal claims that “[s]teel is ... endlessly recyclable: all steel can be re-used indefinitely without loss of quality” and “[t]he ease of separating steel from other materials is due to its magnetic properties and makes steel the most recycled material in the world.” (ArcelorMittal, n.d.). This only focuses on the separability of steel from other materials but not on the elements steel is combined with.

Where steel is contaminated with ‘tramp elements’ – elements difficult to

---

6 Interview with steel and cement experts from the University of Cambridge.
7 Such as copper, tin, chromium, nickel and molybdenum, or – less common – lead, antimony, bismuth and arsenic (Rankin 2011, 284).
remove from metals – it is limited to lower-grade uses, as their removal “re-
quires application of highly selective physical or chemical processes which are
technically difficult and expensive” (Rankin 2011, 284). A product containing
tramp elements is often downgraded for use in less demanding applications, such
as construction rebars.

The media also takes up the narrative of 100% infinite recyclability (see
e.g. Wintermann 2013). However, referencing INSEAD’s Robert Ayres, Allwood
and Cullen (2011, 65) put that estimate closer to a 90% practical maximum.

The amount of energy that the steel industry uses to produce a ton of steel
is becoming very close to the theoretical minimum needed. While the potential
to further increase efficiency exists theoretically, it is very difficult to achieve
further gains. Further improvements are likely to be quite small compared to
the improvements the steel industry witnessed over the last few decades. As a
consequence, most of the environmental impact reduction potential is located
downstream in the supply chain.8

Between 2009 and 2015 Chinese steel exports rose by 400% (Ruddick 2016).
By now China produces about half of global steel output (Pooler 2017). In the
US, the Trump administration eventually responded by imposing a 25 per cent
tariff on steel imports (Crooks and Fei 2018).

Aluminium, wood, stone and concrete are the major contenders for steel sub-
stitution in construction; and aluminium and steel compete in applications such
as automotive (Allwood and Cullen 2011, 46f.).

A.5.2.2. Cement

A major share of industry GHG emissions is from the cement production. Ce-
ment is nearly exclusively used in the building sector, which, in turn is the single
largest contributor to global GHG emissions (Gibbs and O’Neill 2015, 134). Ac-
cording to the World Resource Institute (WRI) of total global emissions in 2005,
cement production accounted for 5.0% of global emissions (The Guardian 2011).
As cement use is tied to construction activity, its consumption fluctuates with
economic growth cycles (Smil 2014, 54).

Portland cement is produced by finely grounding lime, clay and sand, or metal-
lic oxides, and firing the mixture at high temperatures in kilns. The chemical
reactions then result in pellets of clinker (Allwood and Cullen 2011, 292). This

8Interview with steel experts from the University of Cambridge.
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chemical process releases around 0.53 tCO₂ per ton of clinker (Branger and Sato 2015, 6). Whereas about half of the emissions from cement production are due to this reaction, about 40% are due to the heating process (Allwood and Cullen 2011, 292). The clinker is then ground finely with a small amount of gypsum to make cement (Allwood and Cullen 2011, 292).

Together with aggregates and water, cement is the basis for concrete. (Smil 2014, 19). Concrete is the world’s most important construction material (Smil 2014, 45).

For the global level, estimates referenced by the IPCC for the contribution of process-related emissions from cement production for the year 2010 range from 1.352 GtCO₂ to 1.65 GtCO₂ (Fischedick et al. 2014). In relation to overall emissions of 49.5 giga tonnes of carbon dioxide equivalents (CO₂eq) (Victor et al. 2014, 133), this amounts to 2.73% and 3.3%, respectively. Going beyond the process-related emissions, overall emissions from the cement sector are about double as much (Fischedick et al. 2014, 758).

This poses the question of whether one could – in analogy to the phasing-in of renewable energy – substitute cement in the buildings sector with other materials. No other material than cement that is “capable of delivering the same functions [is] available in comparable quantities” (Fischedick et al. 2014, 757). However, for a partial substitution, under conditions of modified building styles, it is not necessary to deliver the completely same functions. Wood, next to rammed earth and other alternative materials, is a major potential, yet only partial, substitute in the building sector (Oliver et al. 2014).

A range of reports have analysed cement and concrete’s carbon reduction potentials (International Energy Agency 2009; World Business Council for Sustainable Development and International Energy Agency 2009; Allwood and Cullen 2011; Vallack et al. 2011). The cement industry seeks to reduce emissions by using different fuel types for heat generation, increasing energy efficiency and by reducing the clinker content of cement. For the latter, clinker is often blended with by-products from coal-firing and virgin steel production to reduce the clinker content in cement. As these are only attributed the emissions of a by-product, cement seems to become less emissions-intensive. While in one way this is indeed the case, this decrease in emissions intensity is only possible on the basis of highly emissions intensive ways of generating electricity and increasing the stock of steel. This could be described as a form of high carbon ‘industrial symbiosis’.
Carbon capture and storage (CCS) is the major technological fix on which hopes for a low carbon cement future rest. CCS for the cement industry is still at an early state of development. Cement producers participate, e.g., in a research project funded by the European Commission in order to develop breakthrough technologies for capturing CO$_2$ (Global Cement 2016).

The association of ancient roman structures with concrete may evoke the idea that modern day concrete would be just as durable, or – in a conflation – sustainable. However, the Romans used a mixture superior to modern concrete, employing, amongst other differences, locally available volcanic sand (Smil 2014, 19). In contrast, modern concrete lacks such high durability and the looming deterioration of immense concrete landscapes makes the world headed for expensive – and potentially highly carbon intensive – renovation, demolition and reconstruction activity (Smil 2014, 55f.).

There are interesting framing effects, which are probably due to the contestation among different building materials producers. The concrete industry seeks to receive recognition in the green buildings certification schemes’ materials sections for the “sustainable sourcing” of concrete as a local material (Concrete Sustainability Council, n.d.; MPA The Concrete Centre, n.d.). This could be seen as counter-framing to limit the role of non-certified timber in the construction industry.

A.5.2.3. Timber

Forests cover roughly 30% of the world’s land surface (Dauvergne and Lister 2011, 21). Planted forests comprise about 7% of global forest area (Adams 2012). China, the US, and Russia account for about half of the world’s timber plantations (Dauvergne and Lister 2011, 13). In the European Union, Sweden, Finland, Germany and France were the top roundwood producers in 2015, and Germany and Sweden were the biggest sawnwood producers (Eurostat n.d.a, n.d.b). One estimate forecasts an increase of global timber consumption by more than 50% by 2050 (from 1990 levels) (Dauvergne and Lister 2011, 32).

According to Allwood and Cullen (2011, 47), before the industrial revolution stone and wood were the dominant materials used by humans. In contrast, Minke (2012, 9) claims that earth has been the predominant building material in nearly all hot-arid and temperate climates, and today, more than half of all people in the developing world reside in earthen houses (I thank Neil May, UCL, for pointing this out).
A. Appendices

and Lister (Dauvergne and Lister 2011, 19) suspect that an increase in the consumption of these substitutes has alleviated some of the global demand for timber.

The governance of forest stewardship and timber trade are considered great environmental challenges (Dauvergne and Lister 2011, 21). Dauvergne and Lister (2011, 23) point out that “[g]overnments and consumers commonly lack any knowledge of the original source or the full environmental and social costs of timber”. The Forest Stewardship Council (FSC) is a major private certification initiative, seeking to fill the governance gap left by nation states. The FSC has been followed by a number of other voluntary labelling standards (Cashore and Stone 2012; Iben, Hansen, and Cashore 2014).

Timber interests pitch their produce by emphasising that forest plantations sequestrate carbon from the air. For example, the American Forest Foundation, amongst whose Board of Trustees one could find, inter alia, the Senior Vice President of Weyerhaeuser, the top US timber producer (American Forest Foundation 2013; Forisk Consulting 2017), praises forestry products as offering “tremendous forest carbon services as ‘natural scrubber systems’ that capture carbon dioxide” (American Forest Foundation 2015). The Confederation of European Forest Owners (CEPF) (2015) also points out “the enormous climate benefit and potential of substitution ... where fossil- and energy intensive materials can be replaced with climate friendly and sustainable wood”. Wood for Good, the UK timber industry’s sustainability and promotion campaign calls increased forest cover “the cheapest, most efficient and effective carbon capture and storage system available” (Wood for Good 2012). The German Wood Council also points to the benefits of carbon sequestration and materials substitution (Deutscher Holzwirtschaftsrat, n.d.).

A report by the European Forest Institute suggests that “both the action of forests and harvested wood products as a carbon sink and carbon stock, and the substitution effect of forest products for fossil-based raw materials and products” produce an overall climate mitigation impact which equals about 13% of total EU emissions (Nabuurs et al. 2015, 3). The authors of the IPCC report chapter dedicated to forestry, and related issues, suggest that increased wood use in construction activities, under the conditions that it is associated with afforestation and reforestation, can help to enhance the sequestration of carbon in soils, biota, and long-lived products. The carbon sequestered by timber products may be released later in the life cycle – for example by use as a fuel
A.5. Background on building materials

– and their mitigation contributions would thus not be considered permanent. However, to the degree that forest products replace fossil fuels or more carbon intensive construction products, these mitigation contribution can be regarded as permanent (P. Smith et al. 2014, 829–32). The IPCC authors point to recent studies, suggesting “that, where technically possible, substitution of wood from sustainably managed forests for non-wood materials in the construction sector (concrete, steel, etc.) in ... buildings, reduces GHG emissions in most cases” (P. Smith et al. 2014, 841).

However, the IPCC report authors of the chapter dedicated to industry strike a less enthusiastic chord, as they note that timber is “kiln dried, so in effect is energy intensive” (Fischedick et al. 2014, 757). However, whereas a switch to renewable energy wouldn’t change anything about chemical process emissions from steel and clinker production, processes that are merely energy intensive can in principle be decarbonised, either by switching to renewable sources of energy or by returning to traditional methods of air-drying wood, which take several months or even years (Gustavsson and Sathre 2006, 945).

There are heated discussions about the extent to which wood could replace steel and cement in buildings and infrastructure, with biodiversity and land use competition with agriculture being major points of contention (Dauvergne and Lister 2011; Bengt Gunnar Jonsson and Svoboda 2015). An in-depth discussion is beyond the scope of this work, even more as the debate itself can already be read as being part and parcel of the contestation between the different materials in the buildings sector.

A.5.2.4. Clay

For clay bricks, non-energy related process emissions are negligible (U.S. Environmental Protection Agency 2015, 3) and bricks can not only be fired with fossil fuel energy carriers but also with biofuels and electricity (Carbon Trust, n.d., 52). There is a clear decarbonisation potential for clay bricks and unfired clay is regarded as a low carbon material (University of Bath Department of Architecture and Civil Engineering 2018).\(^{10}\)

The world’s biggest clay brick producer is part of the ASBP.

\(^{10}\)Interview with Danny Püschel of the Building Alliance.
A. Appendices

A.5.2.5. Hemp and straw

Hemp and straw are niche building products. Hemp is both used as an insulation material (Kymäläinen and Sjöberg 2008) and as a composite material for construction (Bevan and Woolley 2008).

Straw can not only be used for applications such as insulation and roofing thatch but also there are also load-bearing straw bale walls (Walker, Thomson, and Maskell 2016, 127f.).

A.5.3. Interactions between steel and cement

Portland cement has been the dominant type since the nineteenth century. This cement is weak in tension, which can be overcome by reinforcing it with iron. The hydraulic properties of Portland cement, in turn, protects iron from rust (Smil 2014, 28). Cast iron shares concrete’s weakness in tension, which limits its structural use. In contrast, steel injects modern concrete reinforcement with the strength we have all become accustomed to (Smil 2014, 29f.), and nearly all concrete construction is thus reinforced (Allwood and Cullen 2011, 35). Here we can observe a complementary or symbiotic relationship between these material uses. This kind of symbiosis, however, also makes recycling more problematic, as the separation of concrete and reinforcing metals is expensive (Smil 2014, 56).

A.6. Details on embodied emissions advocacy networks

Table A.2 shows organised interests advocating for a greater role for embodied emissions in policy instruments.

The following provides details on the networks of embodied emissions advocates in the Germany, the UK and the USA.
### A.6. Details on embodied emissions advocacy networks

#### Table A.2.: Organised interests advocating for a greater role for embodied emissions in policy instruments

<table>
<thead>
<tr>
<th>Actor</th>
<th>Type</th>
<th>Position on embodied emissions</th>
<th>Region</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hock GmbH &amp; Co. KG</td>
<td>Renewable insulation materials company</td>
<td>as subsidy criterion</td>
<td>Germany</td>
<td>2013</td>
</tr>
<tr>
<td>Bau-Fritz GmbH &amp; Co. KG</td>
<td>Renewable insulation materials company</td>
<td>embodied emissions accounting as subsidy criterion</td>
<td>Germany</td>
<td>2013</td>
</tr>
<tr>
<td>Autodesk</td>
<td>Software company</td>
<td>require digital whole-life-cycle performance passports for buildings</td>
<td>EU</td>
<td>2015</td>
</tr>
<tr>
<td>Innovation and Growth Team</td>
<td>Industry expert group</td>
<td>as public sector procurement criterion – first stage towards regulation of embodied carbon</td>
<td>UK</td>
<td>2010</td>
</tr>
<tr>
<td>Wood for Good</td>
<td>Industry group</td>
<td>should provide a consistent methodology for the assessment of embodied carbon and life cycle assessment in buildings</td>
<td>UK</td>
<td>2011</td>
</tr>
</tbody>
</table>
### A. Appendices

<table>
<thead>
<tr>
<th>Actor</th>
<th>Type</th>
<th>Position on embodied emissions</th>
<th>Region</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green Construction Board</td>
<td>Government-industry body</td>
<td>address embodied emissions in tandem with operational ones</td>
<td>UK</td>
<td>2013</td>
</tr>
<tr>
<td>Timber Accord</td>
<td>Industry group</td>
<td>assessment of whole-life carbon for all buildings</td>
<td>UK</td>
<td>2014</td>
</tr>
<tr>
<td>UK Green Building Council Zero Carbon Non Domestic Task Group</td>
<td>Green building council</td>
<td>embodied carbon regulations for buildings not before 2022</td>
<td>UK</td>
<td>2014</td>
</tr>
<tr>
<td>Steel Construction Institute</td>
<td>Industry think tank</td>
<td>inclusion of embodied emissions in building regulations would be beneficial for steel re-use and recycling (not direct advocacy)</td>
<td>UK</td>
<td>2016</td>
</tr>
<tr>
<td>UK Green Building Council</td>
<td>Green building council</td>
<td>for mainstreaming embodied carbon issue in building sector and seeks to encourage embodied carbon assessment in public sector planning and procurement</td>
<td>UK</td>
<td>2017</td>
</tr>
</tbody>
</table>
### A.6. Details on embodied emissions advocacy networks

<table>
<thead>
<tr>
<th>Actor</th>
<th>Type</th>
<th>Position on embodied emissions</th>
<th>Region</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Embodied Carbon Industry Task Force</td>
<td>Ad-hoc industry expert group</td>
<td>as criterion towards compliance with government ‘zero carbon’ home standard and building regulations should be developed to eventually include whole-life carbon emissions</td>
<td>UK</td>
<td>2014</td>
</tr>
<tr>
<td>Alliance for Sustainable Building Products</td>
<td>Trade association</td>
<td>for ambitious targets for embodied emissions reductions in buildings</td>
<td>UK</td>
<td>2014</td>
</tr>
<tr>
<td>German Sustainable Building Council</td>
<td>Green Building Council</td>
<td>as criterion towards compliance with government Energy Saving Ordinance</td>
<td>Germany</td>
<td>2016</td>
</tr>
<tr>
<td>Actor</td>
<td>Type</td>
<td>Position on embodied emissions</td>
<td>Region</td>
<td>Date</td>
</tr>
<tr>
<td>------------------------------------------------</td>
<td>-----------------------</td>
<td>--------------------------------------------------------------------------------------------------</td>
<td>----------</td>
<td>--------</td>
</tr>
<tr>
<td>Architects’ Council of Europe</td>
<td>Professional association</td>
<td>include embodied energy in energy performance certificates</td>
<td>EU</td>
<td>2013</td>
</tr>
<tr>
<td>Association of German Master Carpenters</td>
<td>Trade association</td>
<td>a criterion for subsidies, tax advantages and public procurement in the buildings sector (not clear whether generally related to embodied emissions or in particular to wood)</td>
<td>Germany</td>
<td>2014</td>
</tr>
<tr>
<td>Deutscher Holzwirtschaftsrat</td>
<td>Trade association</td>
<td>as part of German Sustainability Strategy, as criterion towards compliance with government Energy Saving Ordinance, combine Energy Saving Ordinance and Renewable Heating Law into CO$_2$ Saving Ordinance</td>
<td>Germany</td>
<td>2016</td>
</tr>
</tbody>
</table>
### A.6. Details on embodied emissions advocacy networks

<table>
<thead>
<tr>
<th>Actor</th>
<th>Type</th>
<th>Position on embodied emissions</th>
<th>Region</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gebäude-Allianz</td>
<td>Industry-NGO alliance</td>
<td>make EPD provision obligatory for contractors so that embodied energy can be assessed, too</td>
<td>Germany</td>
<td>2016</td>
</tr>
<tr>
<td>Chamber of Architects Baaden-Württemberg</td>
<td>Professional association</td>
<td>as criterion towards compliance with government Energy Saving Ordinance, which should be further developed into a carbon-oriented regulation</td>
<td>Baaden-Württemberg, Germany</td>
<td>2016</td>
</tr>
<tr>
<td>Buy Clean California supporter group (inter alia Gerdau Steel and U.S. Cement)</td>
<td>Industry-NGO- Trade Union alliance</td>
<td>state procurement of select materials based on carbon-intensity benchmarks</td>
<td>California</td>
<td>2017</td>
</tr>
<tr>
<td>Carbon Leadership Forum</td>
<td>Industry-academic collaboration</td>
<td>its policy task force aims to advance policies for reducing the embodied carbon of buildings</td>
<td>USA</td>
<td>2018</td>
</tr>
</tbody>
</table>
Table A.3 provides the sources for the positions on embodied emissions.

<table>
<thead>
<tr>
<th>Actor</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alliance for Sustainable Building Products</td>
<td>Alliance for Sustainable Building Products (n.d.)</td>
</tr>
<tr>
<td>Central Union of Agricultural Producers and Forest Owners</td>
<td>Central Union of Agricultural Producers and Forest Owners (MTK) (n.d.)</td>
</tr>
<tr>
<td>Association of German Master Carpenters</td>
<td>Holzbau Deutschland – Bund Deutscher Zimmermeister (2014)</td>
</tr>
<tr>
<td>Deutscher Holzwirtschaftsrat</td>
<td>Deutscher Holzwirtschaftsrat (2016a)</td>
</tr>
<tr>
<td>Natureplus</td>
<td>Natureplus (2017)</td>
</tr>
<tr>
<td>Hock GmbH &amp; Co. KG</td>
<td>Hock-Heyl (2013)</td>
</tr>
<tr>
<td>Bau-Fritz GmbH &amp; Co. KG</td>
<td>Müller (2013)</td>
</tr>
<tr>
<td>Architects’ Council of Europe</td>
<td>Architects’ Council of Europe (2013)</td>
</tr>
</tbody>
</table>
A.6. Details on embodied emissions advocacy networks

<table>
<thead>
<tr>
<th>Actor</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chamber of Architects</td>
<td>Chamber of Architects Baden-Württemberg and German Sustainable Building Council (2016)</td>
</tr>
<tr>
<td>Baaden-Württemberg</td>
<td>Ecocem in CDP 2015</td>
</tr>
<tr>
<td>Ecocem</td>
<td>Buy Clean California Kuipers (2017); California Senate Committee on supporter group (inter alia Gerdau Steel and U.S. Cement) Governmental Organization (2017); Melton (2018)</td>
</tr>
<tr>
<td>Gebäu.de-Allianz</td>
<td>Gebäu.de-Allianz (2016a)</td>
</tr>
<tr>
<td>Carbon Leadership Forum</td>
<td>Carbon Leadership Forum (2018b)</td>
</tr>
<tr>
<td>Steel Construction Institute</td>
<td>SCI (the Steel Construction Institute) (2016)</td>
</tr>
<tr>
<td>Wood for Good</td>
<td>Wood for Good (2011)</td>
</tr>
<tr>
<td>Timber Accord</td>
<td>The Timber Accord (2014)</td>
</tr>
<tr>
<td>Innovation and Growth Team</td>
<td>Innovation &amp; Growth Team (2010)</td>
</tr>
<tr>
<td>UK Green Building Council</td>
<td>UK Green Building Council (2017)</td>
</tr>
<tr>
<td>German Sustainable Building Council</td>
<td>German Sustainable Building Council (2016)</td>
</tr>
<tr>
<td>Green Construction Board</td>
<td>Green Construction Board (2013)</td>
</tr>
</tbody>
</table>

A.6.1. Germany

The German Nature and Biodiversity Conservation Union (NABU) coordinates the Building Alliance (Gebäu.de-Allianz). At a NABU Forum on “Climate and resource protection in the building stock” (NABU 2012) in 2012, Dagmar Fritz-Kramer of the Baufritz company argued for a stronger consideration of the
life cycle impacts of building materials in building assessments. Fritz-Krahmer criticised that the Energy Saving Ordinance does not take the embodied energy of construction materials into account and demanded that EPDs, including the values of embodied emissions, should become the basis of building sustainability assessments.\footnote{In 2009 the ecological construction company Baufritz received the German Sustainability Prize (Deutscher Nachhaltigkeitspreis 2009) and in 2013 Fritz-Krahmer, its CEO, received the Environmental Prize of the Federal Working Group for Environmentally Conscious Management (B.A.U.M.), a business network.}

Two years later, at a NABU event at the Berlin Energy Days (Berliner Energietaeg 2014), the need to take into account the overall ecological qualities of buildings, including their building materials was discussed and a more holistic perspective on resource efficiency, instead of solely on energy efficiency, was demanded (NABU 2014).

In the same year’s symposium between the Building Alliance, members of the Federal Parliament and the Economy Ministry, embodied emissions neither were reported as having played a role in the overall discussions (Gebäude-Allianz 2014b), nor in the Building Alliance’s demands (Gebäude-Allianz 2014a). In next year’s 6th symposium by the Building Alliance, the Baufritz company again advocated for the integration of resource efficiency and embodied energy into a reformed Energy Saving Ordinance (Gebäude-Allianz n.d., 2015).

In March 2016 the Building Alliance (Gebäude-Allianz) (2016a), by now a coalition of more than 30 environmental organisations, consumer initiatives, associations, trade unions and companies, released a joint declaration of their demand towards the fusion, simplification and further development of the Energy Savings Law (Energieeinsparungsgesetz) (EnEG), Energy Saving Ordinance (Energieeinsparverordnung) (EnEV) and the Renewable Energy and Heating Law (Erneuerbare-Energien-Wärmegesetz) (EEWärmeG). Amongst the fundamental demands were the consideration of the production, transportation, storage, sale and disposal of building products. More concretely, the Building Alliance asserted that contractors should in the future be required to provide EPDs for the utilised building and insulation materials in order to enable LCAs of the overall energetic performance. Here, energy derived from renewable and fossil sources should be declared separately. The Building Alliance demanded explicitly that the LCA values of technical devices should be available in order to compare the energy savings that can be achieved with them to the energy that is embodied in them (Gebäude-Allianz 2016a, 5).
A.6. Details on embodied emissions advocacy networks

The following month the Building Alliance gathered at the NABU headquarters for a meeting on the merger, simplification and further development of Energy Saving Ordinance and the Renewable Energy Heating Law. Here Taco Holthuizen (2016), architect and CEO of the e+Zeit Ingenieure development company, gave a presentation suggesting that the consideration of embodied energy in the Energy Saving Ordinance could reduce heating bills, save resources and construction costs, reduce significantly more CO$_2$ and lead to full employment.

The company Thinkstep is a key player in the international LCA/EPD scene: In an interview, dated April 2016, Martin Baitz, Director Content at Thinkstep AG suggested that, in the future, Thinkstep’s GaBi LCA database may even serve “as a basis for legal regulations, but that’s not within [their] sphere of influence” (Prox 2016a). In the same month, after 15 years at Thinkstep, which was among the co-founders of the German Sustainable Building Council (DGNB), Johannes Kreißig started as CEO of the DGNB. A month later, in May 2016, the DGNB published a position paper, demanding that the Energy Saving Ordinance be reformed to also take into account embodied carbon (German Sustainable Building Council 2016). Were the government to heed that demand, it would likely turn LCA databases into a basis for legal regulations.

Thinkstep is also a sponsor of the US Carbon Leadership Forum and a co-signatory (under its former name as PE International), together with the ASBP, of a contribution to a BREEAM consultation, with the expressed demand that BREEAM pay more heed to embodied emissions and adopt building-level LCA approaches to the assessment of environmental impacts (The Alliance for Sustainable Building Products and PE International 2013).

In June 2016 the German Energy Consultant Network (Deutsches Energieberater-Netzwerk) (2016) also released a statement calling for a stronger consideration of embodied energy in the Energy Saving Ordinance.

Natureplus is an association with the declared aim of promoting sustainable and healthy building materials, and official partner of the Alliance for Sustainable Building Products (ASBP) (Natureplus 2018). Just as in the case of the British ASBP, the world’s largest brick manufacturer Wienerberger is also represented here, this time via Gerhard Koch from the Verband Österreichischer Ziegelwerke (VÖZ) (Association of Austrian Brick Factories) (Natureplus n.d.).

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12 In 2015 the president, vice-president and treasurer of VÖZ all were Wienerberger managers.
A. Appendices

In June 2016 Natureplus and the *Heinrich-Böll-Stiftung*, the political foundation associated with the German Green party, held a joint conference on sustainable building products. According to Natureplus, the energy embodied in building materials was a major focus of the conference. At the conference, Chris Kühn, the Green’s speaker on construction policy, and Peter Ahmels, of the *Deutsche Umwelthilfe* (DUH) (German Environmental Aid), demanded a support programme for sustainable building materials by the German development bank *Kreditanstalt für Wiederaufbau* (KfW) (Natureplus 2016a). The KfW provides subsidised loans to promote energy efficiency in buildings (Rosenow 2013), and here we can see an attempt to expand its mandate.

In August 2016 Natureplus (2016b), reported that members of this group visited the hemp and jute insulation company Thermo-Natur and had discussions with the chairman of the parliamentary group of the German Green party, Anton Hofreiter, and the construction policy speaker of the Greens, Chris Kühn. According to Natureplus, the company Thermo-Natur had initiated the meeting, which was also attended by its principal shareholder, Alfred Ritter, former CEO of chocolate manufacturer Ritter Sport (Frankfurter Allgemeine Zeitung 2014). At the meeting all invited experts insisted that the focus needed to shift from being solely concerned with heating, to also include the ecological footprints of building materials, in particular their embodied energy.

In July 2016 the Chamber of Architects of the German Land Baaden-Württemberg also joined the DGNB in its demands (2016). They released the results of a common hearing on the fusion of the Energy Savings Law (Energieeinsparungsgesetz) (EnEG), Energy Saving Ordinance (Energieeinsparverordnung) (EnEV) and the Renewable Energy and Heating Law (Erneuerbare-Energien-Wärmegesetz) (EEWärmeG), which the German Federal Government was planning then. The Chamber of Architects and the DGNB demanded that the focus should be shifted from energy saving to climate change mitigation. In tune with this, they asserted that the focus of regulation be extended from the mere use phase of a building to including embodied energy and embodied emissions. Both explicitly combined this demand with a call for technology-openness (German Sustainable Building Council 2016), thus echoing the Federal Government’s insistence on the latter.

In July 2016 the German Wood Business Council (Deutscher Holzwirtschafts-...
A.6. Details on embodied emissions advocacy networks

srat e.V.) (DHWR) (2016a) published its positions towards the reform of the German Sustainability Strategy. Here, it pointed out the importance of embodied energy and called for an approach that takes into account the whole-life cycle of buildings, and products in general.

In November 2016 DHWR released three position papers: One demanded a reform of the Energy Saving Ordinance by taking into account the entire life cycle of buildings, including their embodied energy. The DHWR claimed that its efforts had successfully resulted in the acknowledgement of the climate mitigation contribution of wood and support for wood construction in the German Climate Action Plan 2050 (Klimaschutzplan). Going beyond this, the DHWR suggested that it would be even more in accordance with the implementation of the German Climate Action Plan 2050 to combine the Energy Saving Ordinance and the Renewable-Heating-Law into a new CO$_2$ Saving Ordinance, which would evaluate all measures according to their greenhouse gas potential (Deutscher Holzwirtschaftsrat 2016b).

Another position paper defined the ‘cascading’ use of wood as a practice where wood is used at least twice, either as a material or as an energy carrier (Deutscher Holzwirtschaftsrat 2016c). This logically excludes the direct use of wood as an energy carrier. The DHWR praises the implementation of the cascading use principle as an increase in the climate change mitigation contribution of wood utilisation, as longer cascading use leads to an equally longer storage of the sequestrated carbon in wood products. The advocacy for this cascading use of wood is congruent with an emphasis on the contribution of wood use to climate change mitigation. However, this excludes framings that would merely suggest that the use of wood would be beneficial due to it being a ‘renewable’ resource. In lockstep with the position paper on the cascading use of wood, the German Wood Council went on to assert, after affirming the higher climate change mitigation contribution of using wood as a material than merely as an energy carrier, that the energetic use of wood should occur in the most resource and energy efficient ways possible, taking into account the cascading use principle (Deutscher Holzwirtschaftsrat 2016d).

In disagreement with this position, the German Association for Energy Wood and Pellets (Deutscher Energieholz- und Pelletverband) declared that it would leave the DHWR. It asserts that heating with wood would be climate neutral and thus emphasises the contribution to climate mitigation efforts. Overall, it frames energetic wood use more in terms of it being a climate neutral, renewable
energy, rather than emphasising wood’s potential to sequester carbon or to substitute more carbon intensive use of materials (rather than energy carriers) (Deutscher Energieholz- und Pelletverband 2016).

There is a competition between the use of biomass as an energy carrier and as a material, which is likely to exacerbate (Arnold et al. 2009, 141). Here we see how a framing that focuses on carbon sequestration and the substitution of carbon intensive materials can be levied against one which focuses on an energy carrier being carbon neutral and renewable. Informationsdienst Holz (2016) claims that the DHWR and the German Association for Energy Wood and Pellets indeed parted ways as the latter did not want to support DHWR’s declaration on the cascading use principle, which was published simultaneously with its position on the reform of the Energy Saving Ordinance. This suggests a conflictive potential of the embodied emissions framing, one with the power to re-aggregate interest groups. A DGNB representative also suggested that if embodied emissions were taken into account that the use of biomass for heating would receive a far less favourable reception than today.13

Only a month after the DHWR had published its demand for combining the Energy Saving Ordinance and the Renewable-Heating-Law into a new CO₂ Saving Ordinance, the Building Alliance released a statement that CO₂ as sole criterion for building standards would endanger both energy transition and climate protection. They argue that a pure CO₂ criterion could lead to buildings satisfying this criterion mainly by relying on renewable electricity, which would lead to more demand for electricity overall and higher costs for the inhabitants of buildings. In that statement, the Buildings Alliance does not address the problem of embodied emissions at all (Gebäude-Allianz 2016b).

While the above has focused on instances of industry advocacy in favour of a greater role for embodied emissions, overall such voices have been relatively marginal, with the mainstream of industry being clearly more conservative.

The position paper by the Federal Association of the German Industry (Bundesverband der Deutschen Industrie e.V.) (BDI) (2016c) from July 2016 mentions neither materials nor embodied energy/emissions. A main critique levied by the BDI at the Climate Action Plan 2050 was the perceived lack of technology and energy carrier openness (Bundesverband der Deutschen Industrie e.V. (BDI) 2016b, 2016a).

One may well argue that if there was an objective way of measuring the whole-

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13Interview with DGNB in 2016.
A.6. Details on embodied emissions advocacy networks

Life-cycle emissions of a building, the argument would be weakened that action to address embodied emissions endangers the technology and material openness of building policies. In the absence of such a methodology, direct subsidies or preferences for, e.g., wood construction, would indeed impinge on the technology and material openness. Here we see the potential for product level disclosure to undermine a central argument for not including embodied emissions in the Energy Saving Ordinance or eventual successors.

The December 2015 position paper by the Alliance for Energy Efficiency in Buildings (Allianz für Gebäude-EnergieEffizienz (geea) 2015), (Allianz für Gebäude-Energie-Effizienz) (geea), which is initiated and coordinated by the German Energy Agency (Deutsche Energe-Agentur) (dena), a private public partnership, also does not mention embodied energy/emissions. In its response to the Federal government’s Climate Action Plan 2050, which suggests that climate change mitigation efforts in the built environment should not just focus on a building’s use phase (Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit 2016, 39f.), the geea insists that energy-related criteria and claims should remain central to information, evaluation and subsidy systems. For them, climate aspects need to be integrated into the existing energy-centric system, rather than substituting it (Allianz für Gebäude-Energie-Effizienz (geea) 2016, 6).

A.6.2. Reasons for not including important players in material constituents assessment

Unlike Natureplus, the German Sustainable Buildings Council (DGNB) was not included in the comparative analysis of the building materials offered by the constituents of the embodied emissions network. The following presents the rationale for focusing on Natureplus as representative of the embodied emissions constituency, and for analysing its membership composition in terms of different materials and service providers, rather than on the DGNB: First, life cycle interests in the form of Thinkstep and its academic partner were already amongst the DGNB’s founding members and at the time of its more significant embodied emissions advocacy statements its CEO had just switched from its former job at Thinkstep (see above). Thus, LCA interests and ideas can be deemed to be deeply embedded into the organisational structure of the DGNB.

14A more fitting term would probably be subsumption; however I chose to closely retain the language of the original assertions.
A. Appendices

Second, the DGNB, as a provider of a voluntary sustainable buildings certification scheme, should have an interest to stay ahead of the government in terms of its position as a reformer. Third, the DGNB membership has some overlap with that of “Energy Efficiency First” initiatives, which suggests that either not all of its members truly share its demands for a greater role for embodied emissions, or that they do not have coherent policy positions as expressed by their organisational memberships.

Concerning the last point, Figure A.1 shows the overlap between embodied emissions and ‘Efficiency First’ Networks. Most member organisations are depicted as small blue dots whereas embodied emissions advocates, and ‘Energy First’ advocates are shown bigger and in colour. The following organisations are shown with a label:

- ‘Energy Efficiency First’ advocates:
  - German Business Initiative for Energy Efficiency (DENEFF)
  - Alliance for Energy Efficiency in Buildings (geea)

- Embodied emissions advocates
  - German Sustainable Building Council (DGNB)
  - Natureplus
  - Gebäude-Allianz (Building Alliance) (GA)
  - Deutscher Holzwirtschaftsrat (DHWR)

In addition, the B.A.U.M. environmental management business network is also shown. B.A.U.M. itself is a member of the Building Alliance and some of its individual members belong to other organisations.

We can see that there is no overlap between DHWR and Natureplus on the one hand, who are both focussed on promoting particular types of low-embodied emissions materials, and the ‘Energy Efficiency First’ advocates, on the other hand. In contrast, we can observe overlaps between GA and DGNB, who pursue embodied emissions within a more overarching sustainability frame, and the ‘Energy Efficiency First’ advocates.\(^{15}\)

\(^{15}\)This is not to say that Natureplus may not have overlap with other ‘Efficiency First’ organisations that were not included in the analysis.
This suggests that an analysis of the DGNG membership may be less suitable for inferring the interest behind advocacy for embodied emissions policies than those of other actors.

Can we see a business-driven advocacy for a greater consideration of embodied emissions in the efforts by the Building Alliance? Some evidence would support the affirmative: Notable business representatives among the coalition were B.A.U.M., Bundesverband Erneuerbare Energie e.V. (BEE), Deutsche Unternehmensinitiative Energieeffizienz (DENEFF), Deutscher Energieholz- und Pellet-Verband e.V., VDKF Verband Deutscher Kälte-Klima-Fachbetriebe e.V. and WDVSysteme (Fachverband Wärmedämm-Verbundsysteme e.V.). According to B.A.U.M., with over 500 members it is the biggest company network for sustainable business in Europe (B.A.U.M. 2018). BEE is an umbrella association of the renewable energy sector in Germany. Amongst DENEFF’s members feature prominent businesses such as 3M, Bosch, ROCKWOOL, E.On, Knauf Insulation, Philips, PricewaterhouseCoopers, Schneider Electric, Siemens, Velux and Veolia (DENEFF 2018). Trades were represented by *inter alia* the Bund Deutscher Innen Architekten, Vereinigung freischaffender Architekten and the Bundesverband Gebäudeenergieberater Ingenieure Handwerker e.V.

However, an interview with the coordinator of the campaign suggests that this advocacy for a greater consideration of embodied emissions was *not* driven by the material interests of these large businesses, which were associated with the coalition, sometimes mediated via membership in another organisation: Danny Püschel coordinated the Building Alliance as part of his job as NABU spokesperson for energy and climate policy. Püschel is an ecologist by training and, in an interview, he claimed that he has brought the LCA agenda from his prior job related to building ecology. In August 2017 he was still working for a company that conducts LCAs for buildings and produces EPDs. He thus brings a strong LCA and EPD perspective to his work at the NABU. Concerning the position paper issued by the Building Alliance, where it demands a greater consideration for LCA in building policy, the only other organisations from within the Building Alliance, which supported it, where other environmental NGOs (Interview with Danny Püschel in August 2017.).

As the coordinator of the Building Alliance also works in a company that

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16 B.A.U.M. has a range of prominent members, e.g. Accenture, adidas, Autodesk, Beiersdorf, BNP Paribas, Canon, Commerzbank, Danone, Deutsche Post, Deutsche Telekom, Porsche, Henkel, Hewlett Packard, Holcim, IKEA, Robert Bosch, Siemens, and Unilever.
Figure A.1.: Overlap between embodied emissions and ‘Efficiency First’ networks in Germany
assists with LCA calculation and EPD generation, one could argue that he at least inhabits the same epistemic space with the LCA consultant community and would also stand to materially benefit from a greater role for LCAs and EPDs. This is not to say that the advocacy is necessarily driven by self-interest, as members of the LCA community may well have started out in their professions due to genuine concerns for the environment.

Further evidence points to a lack of genuine business interest behind the Building Alliance’s advocacy for a greater role for embodied emissions: While the German Business Initiative for Energy Efficiency (DENEFF) forms part of the Building Alliance, and had its seal on its position paper demanding a greater role of LCA in buildings, its position paper on the Climate Action Plan 2050 from September 2016 does not take up any of the points on reducing life cycle emissions in buildings but purely asserts the importance of an “Efficiency First” approach, and reiterates the idea of improving efficiency in a technology-open way (Deutsche Unternehmensinitiative Energieeffizienz e.V. (DENEFF) 2016).

A.6.3. UK

In 2010 the Innovation and Growth Team (2010, 26ff.), a body drawn from the UK construction industry recommended to work towards expanding the public sector procurement guide, the Green Book, with a methodology for a whole-life carbon assessment and to eventually include whole-life carbon as a criterion in the building regulations.

Advocacy for action on embodied emissions was among the main reasons why the Alliance for Sustainable Building Products (ASPB) was founded. As green construction was and still is mainly focussed on operational energy use, the ASPB was formed by a group of companies who saw themselves as producing more sustainable construction products, often from natural materials. One of the benefits of these construction products was low embodied carbon.\footnote{Interview with Gary Newman, ASBP, in August 2017; Interview with Neil May, former director of the ASBP, in March 2018.}

Some of the companies who would eventually found the ASBP came first together in 2008, to discuss the issue of embodied carbon, and ASBP was launched in November 2011. Their first initiative was a heavy critique of the Green Guide, attacking the way it dealt with issues concerning embodied energy, in particular regarding carbon sequestration. Many of the member organisations joined
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ASBP because of the embodied emissions topic.  

Figure A.2 shows the occurrences of keywords related to the LCA/EPD/PCF topics on the ASBP website. We can see that at least from 2013 onwards these topics are frequently discussed in ASBP documents.

The Alliance for Sustainable Building Products (ASBP) and Thinkstep, an LCA database provider and industry consultancy, in a consultation on the further development of the green buildings certification scheme predominant in the UK, states that “BREEAM is not encouraging best practice in the specification and use of products and materials” and demand that “BREEAM should increase the proportion of credits available for materials and consider having a mandatory element” (The Alliance for Sustainable Building Products and PE International 2013).

The ASBP seeks to influence policy via the Royal Institute of Chartered Surveyors, the latter of which, according to the ASBP’s Gary Newman, have a strong interest in the issue of embodied carbon being developed, and who released a Methodology to calculate embodied carbon in 2014 (Royal Institution of Chartered Surveyors 2014).

The ASBP praises a range of building materials’ contribution to lowering embodied carbon, amongst these clay, cellular glass blocks, wood, wool, straw, hemp, timber and low carbon concrete (Alliance for Sustainable Building Products n.d.). This, and ASBPs member list, shows the range of material suppliers

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18 Interview with Gary Newman, ASBP.
20 Disclaimer: The authors main academic affiliation, the UCL Institute for Sustainable Resources (ISR), is listed as founding member of the ASBP. The author was not involved in that and is not aware of any conflict of interest.
21 Interview with Gary Newman, ASBP.
A.6. Details on embodied emissions advocacy networks

Figure A.2.: Occurrence of LCA/EPD/PCF related keywords in documents on the ASBP website
that can rally behind the banner of embodied carbon.

In 2013 the Green Construction Board (GBC), consisting of both representatives from the UK Government and industry, demanded that capital carbon, including GHG emissions embodied in building products, be addressed (Green Construction Board 2013, 4). EPDs were supposed to provide the necessary carbon performance data for materials (ibid, p.5).

Another target for ASBP lobbying is the UK Green Building Council (UK-GBC).

In 2014 the UK Green Building Council’s Zero Carbon Non-Domestic Task Group (2014, 4/8) suggested that government policy should gradually begin to address embodied carbon in construction.

While the UK Green building Council Zero Carbon Non Domestic Task Group could be considered a blocking group as it sought to defer embodied carbon regulations to a later date, it did affirm the desirability of such action in the not too distant future and, as such, seems be more in the camp of supporters than those actors who may wish to keep embodied emissions off the agenda by either not addressing it or emphasising the importance of energy efficiency, instead.

The UK timber industry is a strong advocate for a greater role of embodied emissions, having demanded that government should provide a consistent methodology for the assessment of embodied carbon and LCA in buildings (Wood for Good 2011) and make sure that whole-life carbon should be considered for all buildings (The Timber Accord 2014). Wood for Good, a partnership between Confor and Swedish Wood, commissioned the development of life cycle analysis data on the embodied carbon in construction timber. Such data was, for example, used in the preparation of an EPD for UK Sawmillers’ kiln dried timber (Stiven 2016, 8).

Proponents of steel-reuse are an interesting case within the coalition for a greater consideration for embodied emissions: SCI (the Steel Construction Institute) (2018a) markets itself as “the leading, independent provider of technical expertise and disseminator of best practice to the steel construction sector”. Yet it is also “particularly interested in reusing, as opposed to the common practice of recycling, structural steel” (SCI (the Steel Construction Institute) 2018b).

This goes clearly beyond the defence of incumbent practices. In a policy paper, published on the ASBP’s website,

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22 Interview with Gary Newman, ASBP.
23 Interview with Gary Newman, ASBP.
24 However, in July 2017 I could not find SCI itself among the list of members on the ASBP’s website.
“What is lacking is any legislative incentive to reuse structural steel. Several initiatives have been started to encourage greater reuse and recycling of construction products and materials ... but since the 2008 recession .. UK Governments have ... reduced regulation on constructors and this has included the removal of several sustainability measures including the Code for Sustainable Homes, Site waste management plans, Zero carbon homes targets, etc. In general therefore, there is significantly fewer legislative incentives and drivers for sustainable construction in the UK, including measures to encourage building end-of-life recovery, recycling and reuse.” (SCI (the Steel Construction Institute) 2016)

For them, ”[m]easures developed over the last few years which were designed to encourage reuse and recycling include:

- Inclusion of credits for reuse within BREEAM (BRE rejected this on the basis that they did want to be seen as favouring certain material groups, in this case steel)

- WRAP reuse and recycled content targets

- Proposal to include embodied carbon within the Building Regulations (Approved Document Part L)

- Proposal to include embodied carbon reductions as an allowable solutions under the proposed zero carbon building targets.” (SCI (the Steel Construction Institute) 2016)

Here one can see that the SCI clearly suggests that a greater consideration of embodied carbon would advance one of its main focus areas: the reuse of structural steel. But one can also see that such support for steel re-use can be achieved through various means, with embodied emissions policies only being on option. So, here we have another example of how particular parts of the steel industry can have an interest in advancing the embodied emissions agenda. However, clearly, here this is far from business as usual, as it is predominantly conducted, but with a far greater emphasis on shifting the adding of value from materials production to services. SCI itself does not only point out some of the potential benefits of greater regulation on embodied carbon, it also offers
the carbon footprinting of construction products as a service (SCI (the Steel Construction Institute), n.d.).

The pro-active positions of companies such as AECOM25, Atkins, Arup, British Land26, and Skanska (see Table 5.1) suggests that leading developers and consultants can live quite comfortably with moving targets and policies for construction and may even benefit from their – compared to many smaller competitors – perhaps greater ability to navigate these changing waters.

A.6.4. Overlap between Germany and the UK

Manufacturers active in the embodied emissions field tend to be niche. One exception is Wienerberger27: The world’s largest brick manufacturer (Ficenec 2014) is a founding member of the ASBP and, via Gerhard Koch from the Verband Österreichischer Ziegelwerke (VÖZ) (Association of Austrian Brick Factories), also a member of Natureplus (Natureplus n.d.).28 Wienerberger offers EPDs for its products (Wienerberger, n.d.a), and has announced a partnership for the procurement of renewable energy. The embodied energy savings resulting from the use of renewable energy can then be communicated by EPDs (Wienerberger, n.d.b).

A.6.5. USA

In the USA there are two particularly important loci of embodied emissions advocacy: the University of Washington’s Carbon Leadership Forum (CLF) and the Buy Clean California coalition.

The CLF is a “professional community of manufacturers, designers, builders and academics focused on reducing the carbon ‘embodied’ in building materi-

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25 AECOM is among the organisations with the most self-proclaimed experts on LCA, according to LinkedIn (see AUTHOR, under review).

26 British Land (BL) has been exploring embodied carbon on their developments since 2009 and since 2011 they have started to design out “material usage and [specify] lower carbon sources of concrete, steel, rebar, aluminium and glass” (ibid., p. 57). In 2012 BL also scored a top position in CDP’s annual ranking of the carbon reporting and disclosure efforts of FTSE 350 companies (Korosec 2012; British Land 2015, 20). BL suggests that it intends to “play a key role in the debate around embodied carbon in construction” (British Land 2015, 12). As such, they “co-sponsored the UK Green Building Council’s first Embodied Carbon Week” and one of their representatives chaired the UK GBC’s Zero Carbon Buildings Task Force (British Land 2015, 17).

27 Interview with Gary Newman, ASPB.

28 In 2015 the president, vice-president and treasurer of VÖZ all were Wienerberger managers (Verband Österreichischer Ziegelwerke n.d.), which suggests that the trade association is controlled by the company.
A.6. Details on embodied emissions advocacy networks

The CLF is convener of the Embodied Carbon Network (n.d.), one of whose task forces is dedicated to “advancing successful policies to reduce the embodied carbon of buildings” (Carbon Leadership Forum 2018b). Amongst the CLF’s sponsors are familiar names from the German and UK embodied emissions networks: Built environment services providers Arup, Skanska, and LCA database vendor Thinkstep (Carbon Leadership Forum n.d.).

Working with the CLF to establish their industry-wide EPDs that cover over 2000 different mixes of concrete, the National Ready Mix Concrete Association (NRMCA) were among the first to roll out EPDs for building products at large scale. In 2014 70 companies and 2,300 concrete plants in the ready-mix concrete industry participated in the US National Ready-Mix Concrete Association’s (NRMCA) industry-wide Environmental Product Declaration (EPD). In a press release, Aggregate Industries US, a Holcim subsidiary, pointed out that “[i]n order to gain LEED v4 credit, a project is required to use at least 20 products that have EPDs” (Aggregate Industries US 2014).

It would be problematic to claim that simply because an organisation is affiliated with another organisation active in the field of advocacy for more embodied emissions, that this organisations would then automatically also be amongst the advocates. There can be different reasons for being a member of an organisation, for example a commercial but not a political interest in developing EPDs could give rise to a membership with the CLF. This seems to have been the case with the NRMCA. In LEED 2009 points were available for the use of recycled steel and local or FSC-certified wood, but not to concrete. The introduction of EPDs made points available to cement products, too (Malin 2012). As LEED 4 provided incentives for using EPD-certified products, concrete suppliers developed an interest in coming forward with these (Malin 2012). Thus concrete suppliers may have developed an interest in coming up with EPDs, and thus, perhaps inadvertently, also supporting the epistemic foundation for EPD-based policies.

Thus, allocating concrete suppliers to the group of embodied emissions advocates would require a better justification than mere membership of the Carbon Leadership Forum.

The following looks at important actors supporting or opposing the Buy Clean California Act (BCCA).

The BCCA had both proponents and adherents among cement and concrete

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29 Interview with USGBC in 2017.
A. Appendices

producers. Low carbon concrete company U.S. Concrete, a founding member of the Carbon Leadership Forum (represented via its subsidiary Central Concrete), was a major backer of the bill (Kuipers 2017; California Senate Committee on Governmental Organization 2017; Melton 2018).

While the National Ready Mixed Concrete Association (NRCMA) has been an earlier promoter of EPD adoption and was involved in the initial formulation of the bill, it remained neutral on the inclusion of concrete in the Buy Clean California Act. However, it claims to not have stayed on the sidelines because it opposes the consideration of embodied emissions but because, instead of just comparing EPDs, it advocates for whole-building LCAs (Melton 2018).

It is interesting that the NRCMA refused to support the Buy Clean California bill, as it did not include whole-life building LCAs. Such LCAs would have gone beyond what LEED was prescribing at the time. While the NRCMA may have stayed on the sidelines, the Spragues’ Ready Mix company came out in open opposition (California Assembly Committee on Natural Resources 2017).

In 2018, the NRCMA came out in open opposition against the attempt to replicate the Buy Clean California in form of a Buy Clean Washington act (Washington State Legislature House Committee on Capital Budget 2018), arguing inter alia that “EPDs are complex and costly for small business” (Build with Strength (A Coalition of the National Ready Mix Concrete Association) 2018, 15), which would apply, too, in a scenario where whole building LCAs were conducted on the basis of EPDs.

Just as in the case of California, the NRCMA also did not come up with an alternative proposal for whole building LCAs on the basis of EPDs. While one could interpret the critique of the Buy Clean acts on the basis of the supposedly superior solutions of whole building LCAs as an endorsement of such, clearly the NRCMA did not further advance these proposals and therefore need not be allocated to the block of advocates for embodied emissions policies.

Amongst other reasons for opposing the Buy Clean California Act the California Construction and Industrial Materials Association (CalCIMA), a trade association representing major cement and concrete manufacturers in California, pointed out that only 3 of its 80 member companies had EPDs so far (Melton 2018). In a hearing on April 2017 a representative of CalCIMA said they would oppose the bill “unless amended to remove concrete”.

According to the Kathryn Phillips, Director of the Sierra Club California, other cement producers, Cemex, CalPortland and Lehigh Hanson also came out
against the Buy Clean California Act.

The case of steel is particularly interesting, as here both businesses and trade unions came out in support for the BCCA. After investing millions into switching to renewable energy, Gerdau Steel, whose Vice President Mark Olson explicitly points out competitive disadvantages vis-a-vis less regulated competitors outside of California, helped craft the bill (Kuipers 2017). The California Metals Coalition (2017a), a metals industry trade association, also supported the Buy Clean California act. The United Steelworkers trade union also came out in support (California Senate Committee on Governmental Organization 2017).

While there is no direct membership of wood interests in the two major embodied emissions advocacy organisations in the USA, the Athena Sustainable Materials Institute, who is a member of the Carbon Leadership Forum, produced an international policy review on “Embodied Carbon of Buildings” for the Forestry Innovation Investment Ltd. of Vancouver, B.C. Canada (O’Connor and Bowick 2016). While the wood sector does support the Athena Institute’s work, and thus, indirectly, the Carbon Leadership Forum, Athena also receives support from the Cement Association of Canada, and has iron and steel interests amongst its members and Board of Directors (Institute 2018a, 2018b, 2018c). It thus seems not plausible to allocate the Athena Institute to the block of wood interests.

A.7. Material analysis

The following analyses the materials and services associated with the organisations that were identified as the most pure representatives of embodied emissions advocates.

Data on the different materials supplied was collected in September 2018. Many building material suppliers list various materials. Accordingly, the overall number of materials mentioned is higher than the number of providers counted. Due to the sheer variety of different materials on offer, the list is not exhaustive but focuses on the most prominent materials on a provider’s website.

Table A.4 shows that wood, clay and hemp interests as well as service providers are the most numerous groups among the Natureplus membership (based on analysis of membership data on website in 2018).
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**Table A.4.: Composition of Natureplus in terms of material and service provision mentions**

<table>
<thead>
<tr>
<th>Material</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>wood</td>
<td>19</td>
</tr>
<tr>
<td>wood insulation</td>
<td>11</td>
</tr>
<tr>
<td>clay</td>
<td>9</td>
</tr>
<tr>
<td>hemp insulation</td>
<td>7</td>
</tr>
<tr>
<td>paper insulation</td>
<td>5</td>
</tr>
<tr>
<td>building development and consulting</td>
<td>5</td>
</tr>
<tr>
<td>testing laboratory</td>
<td>4</td>
</tr>
<tr>
<td>wood flooring</td>
<td>4</td>
</tr>
<tr>
<td>building biology experts</td>
<td>4</td>
</tr>
<tr>
<td>ecological building organisation</td>
<td>4</td>
</tr>
<tr>
<td>natural paints</td>
<td>3</td>
</tr>
<tr>
<td>clay bricks</td>
<td>2</td>
</tr>
<tr>
<td>foam glass</td>
<td>2</td>
</tr>
<tr>
<td>hemp</td>
<td>2</td>
</tr>
<tr>
<td>jute insulation</td>
<td>2</td>
</tr>
<tr>
<td>lime</td>
<td>2</td>
</tr>
<tr>
<td>wool insulation</td>
<td>2</td>
</tr>
<tr>
<td>building product certifier</td>
<td>2</td>
</tr>
<tr>
<td>environmental measurement and testing</td>
<td>2</td>
</tr>
<tr>
<td>environmental NGO</td>
<td>2</td>
</tr>
<tr>
<td>cement</td>
<td>1</td>
</tr>
<tr>
<td>coco insulation</td>
<td>1</td>
</tr>
<tr>
<td>concrete restoration</td>
<td>1</td>
</tr>
<tr>
<td>cork insulation</td>
<td>1</td>
</tr>
<tr>
<td>diverse building products</td>
<td>1</td>
</tr>
<tr>
<td>mineral insulation</td>
<td>1</td>
</tr>
<tr>
<td>natural materials</td>
<td>1</td>
</tr>
<tr>
<td>natural stone</td>
<td>1</td>
</tr>
<tr>
<td>renewable building materials</td>
<td>1</td>
</tr>
<tr>
<td>steel</td>
<td>1</td>
</tr>
<tr>
<td>straw</td>
<td>1</td>
</tr>
<tr>
<td>building coatings</td>
<td>1</td>
</tr>
</tbody>
</table>
It is interesting that one of the materials providers affiliated with Natureplus offers steel. However, steel is only one amongst different building materials supplied, with the other being more in line with the Natureplus profile. There is also one cement and concrete company member of Natureplus, Eqiom, a subsidiary of CRH. This seems to be a case of the odd one out, without any immediately apparent reason why this company is part of Natureplus (compare
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CRH 2016), whereas other, similar, companies are not.

Table A.5 shows the composition of the ASBP in terms of materials and services provided by its members (based on analysis of membership data on website in 2018). We can see that wood, hemp, wool and clay are among the dominant materials, and that sustainable building service providers also comprise a substantial proportion of members.

Table A.5.: Composition of ASBP in terms of material and service provision mentions

<table>
<thead>
<tr>
<th>Material</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>building sustainably</td>
<td>13</td>
</tr>
<tr>
<td>wood</td>
<td>10</td>
</tr>
<tr>
<td>hemp</td>
<td>6</td>
</tr>
<tr>
<td>wool</td>
<td>5</td>
</tr>
<tr>
<td>clay</td>
<td>4</td>
</tr>
<tr>
<td>wood insulation</td>
<td>4</td>
</tr>
<tr>
<td>lime</td>
<td>3</td>
</tr>
<tr>
<td>glass insulation</td>
<td>2</td>
</tr>
<tr>
<td>LCA</td>
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</tr>
<tr>
<td>straw</td>
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</tr>
<tr>
<td>biocomposites</td>
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</tr>
<tr>
<td>bamboo</td>
<td>1</td>
</tr>
<tr>
<td>cork</td>
<td>1</td>
</tr>
<tr>
<td>grass insulation</td>
<td>1</td>
</tr>
<tr>
<td>jute</td>
<td>1</td>
</tr>
<tr>
<td>paper insulation</td>
<td>1</td>
</tr>
<tr>
<td>brick rehabilitation</td>
<td>1</td>
</tr>
<tr>
<td>clay bricks</td>
<td>1</td>
</tr>
<tr>
<td>eco-paint</td>
<td>1</td>
</tr>
<tr>
<td>feathers</td>
<td>1</td>
</tr>
<tr>
<td>formaldehyde detection</td>
<td>1</td>
</tr>
<tr>
<td>lime-wood</td>
<td>1</td>
</tr>
<tr>
<td>mineral paint</td>
<td>1</td>
</tr>
<tr>
<td>paper and cardboard bricks</td>
<td>1</td>
</tr>
<tr>
<td>recovered wood fibre from waste MDF</td>
<td>1</td>
</tr>
<tr>
<td>recycled aggregates</td>
<td>1</td>
</tr>
</tbody>
</table>
### A.8. Cement topics

<table>
<thead>
<tr>
<th>Material</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>recycled cotton insulation</td>
<td>1</td>
</tr>
<tr>
<td>repair</td>
<td>1</td>
</tr>
<tr>
<td>sisal</td>
<td>1</td>
</tr>
<tr>
<td>steel re-use</td>
<td>1</td>
</tr>
<tr>
<td>temporary construction</td>
<td>1</td>
</tr>
</tbody>
</table>

Table A.6 shows the material interests represented in the Buy Clean California (BCC) coalition (based on Buy Clean 2017b, 2018; Melton 2018; California Metals Coalition 2017b). In contrast to the comparison groups from UK and Germany, the BCC group also comprises two trade unions associated with specific materials, one of steel and another of metal workers, more generally.

Table A.6.: Composition of Buy Clean California coalition in terms of material and service provision mentions

<table>
<thead>
<tr>
<th>Material</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>metal</td>
<td>2</td>
</tr>
<tr>
<td>steel</td>
<td>2</td>
</tr>
<tr>
<td>concrete</td>
<td>1</td>
</tr>
</tbody>
</table>

### A.8. Cement topics
### Table A.7: Words with the highest probability and exclusive words to the cement-related topics modelled from the WBCSD corpus

<table>
<thead>
<tr>
<th>Topic</th>
<th>Words both frequent and exclusive</th>
<th>Words with highest probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement Sustainability Initiative</td>
<td>esia, csi, battelle, wwwwbcscement-torg, cement, memorial, tolba, kpi, task, mostafa</td>
<td>cement, industry, companies, emissions, csi, materials, initiative, development, co2, sustainability</td>
</tr>
<tr>
<td>Cement and Concrete Mixes and LCA</td>
<td>lca, concrete, slag, portland, cement, ash, fly, cements, clinker, grinding</td>
<td>cement, industry, concrete, materials, environmental, use, lca, process, can, production</td>
</tr>
<tr>
<td>Cement Industry Raw Material Extraction</td>
<td>quarry, limestone, karst, cave, quarries, quarrying, restoration, terre, extractive, blasting</td>
<td>limestone, environmental, area, site, cement, water, industry, plant</td>
</tr>
<tr>
<td>Emissions and Waste as a Fuel</td>
<td>rdf, pcdd, coincineration, kilns, teq, ng, msw, helge, dioxin, furans</td>
<td>emissions, cement, waste, emission, kilns, data, fuel, table, kiln, rdf</td>
</tr>
</tbody>
</table>
### A.8. Cement topics

<table>
<thead>
<tr>
<th>Topic</th>
<th>Words both frequent and exclusive</th>
<th>Words with highest probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement Industry and / as Stakeholders</td>
<td>communication, stakeholder, battelle, substudy, facility, involvement, decision, stakeholders, guidebook, communicate</td>
<td>cement, stakeholder, industry, stakeholders, company, community, environmental, plant, sustainable, issues</td>
</tr>
</tbody>
</table>
A. Appendices

A.9. Documents on the Wayback Machine WBCSD website mirror

Table A.8.: Wayback Machine statistics on HTML and PDF files on the WBCSD website

<table>
<thead>
<tr>
<th>Year</th>
<th>HTML captures</th>
<th>HTML URLs</th>
<th>HTML new URLs</th>
<th>PDF captures</th>
<th>PDF URLs</th>
<th>PDF new URLs</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>4,405</td>
<td>3,417</td>
<td>2,061</td>
<td>727</td>
<td>634</td>
<td>308</td>
</tr>
<tr>
<td>2009</td>
<td>2,063</td>
<td>1,003</td>
<td>696</td>
<td>147</td>
<td>87</td>
<td>29</td>
</tr>
<tr>
<td>2010</td>
<td>2,016</td>
<td>700</td>
<td>426</td>
<td>94</td>
<td>79</td>
<td>45</td>
</tr>
<tr>
<td>2011</td>
<td>2,894</td>
<td>1,186</td>
<td>592</td>
<td>193</td>
<td>79</td>
<td>65</td>
</tr>
<tr>
<td>2012</td>
<td>5,330</td>
<td>2,364</td>
<td>1,840</td>
<td>223</td>
<td>107</td>
<td>54</td>
</tr>
<tr>
<td>2013</td>
<td>2,830</td>
<td>1,245</td>
<td>542</td>
<td>135</td>
<td>53</td>
<td>8</td>
</tr>
<tr>
<td>2014</td>
<td>1,166</td>
<td>684</td>
<td>268</td>
<td>20</td>
<td>12</td>
<td>2</td>
</tr>
<tr>
<td>2015</td>
<td>1,830</td>
<td>712</td>
<td>290</td>
<td>21</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>2016</td>
<td>2,027</td>
<td>860</td>
<td>276</td>
<td>50</td>
<td>37</td>
<td>13</td>
</tr>
</tbody>
</table>

A.10. Keywords related to LCA, EPDs and PCF


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A.11. Details on overlap between IPPC process and LCA releases

In 1998 the Board of Directors of the International Aluminium Institute formally initiated the worldwide collection of aluminium data to be used in LCAs (International Aluminium Institute 2007, 3). This coincides with the year when the BREF process for non-ferrous metals, under which aluminium is grouped, started.

When the CSI was initiated in 1999, the elaboration of the BREF for cement and lime was still on-going (World Business Council for Sustainable Development Cement Sustainability Initiative 2012, 4). As this paper shows the CSI was an important contributor to making sectorally representative cement LCA data available.

According to Ledgard et al. (n.d., 4) Fertilizers Europe (formerly European Fertilizer Manufacturers Association) had initiated a project to develop new LCI data for a number of the main fertilisers used in Europe, based on site-specific fertiliser manufacturing data from a range of EU countries. The data was modelled for the year 2006, the final year of the BREF elaboration process for fertilisers (Brentrup and Pallière, n.d., 12).

Corrugated board consists of paper. One estimate put the global market for corrugated packaging at worth $150.1 billion (ReportBuyer 2016). In 1997 the European Federation of Corrugated Board Manufacturers (FEFCO), Groupe-ment Ondulé and the Kraft Institute published the European Database for Corrugated Board Life Cycle Studies; the same year when the BREF elaboration process for the pulp and paper industry began (Beaufort and Stahel 1998; Schoenberger 2009, 1529). Apart from the said database, the only LCA study

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30FEFCO is, at least indirectly, linked to the IPPC process, too. The British Confederation of Paper Industries (CPI) is affiliated with FEFCO. CPI (Confederation of Paper Industries, n.d.) states that it has “close links” with the IPPC Sounding Board, which, according to the UK Foreign and Commonwealth Office’s Nicholas Hacket (2008), had been set up during the negotiation of the IPPC Directive and comprised about 20 UK industry associations.
A. Appendices

in Gaudreault and Vice’s (2011) 150+ pages Summary of the Literature on the Treatment of Paper and Paper Packaging Products Recycling in Life Cycle Assessment which unequivocally stems from European industry sources is the one on graphic paper and print products by the German publishing house Axel Springer, the Finish-Swedish paper and wood producer Stora (now Stora Enso), and the British Columbia-based pulp and paper supplier Canfor (Axel Springer Verlag AG, Stora, and Canfor 1998a, 1998b). They published their study in 1998, the first half of the BREF elaboration process.

Plastics Europe already published its first Eco-profiles in 1993. However, Plastic Europe notes that the year 2005 is marked as the publication of their Eco-profile methodology as a stand-alone report (Plastics Europe 2011, 10). This was about mid-way through the elaboration of the BREF on polymers.

While the present author could not find a general European refineries LCI, the first release of Eurobitume’s bitumen LCI in 1999 (Blomberg, Bernard, and Southern 2012) coincided with the refineries BREF process.

In 1993 the European Commission (1993) published their Proposal for a Council Directive on Integrated Pollution Prevention and Control. Beginning in 1995 or earlier31, the European Commission’s Directorate-General XII, Research and Development Policy, took responsibility for the Steel Environment Programme, which consisted in the compilation of an inventory of emissions by different sectors of the steel industry, with the aim to identify and evaluate appropriate techniques for the reduction of emissions. In 1996 DG Environment expressed an interest in assuming responsibility for the programme and updating it for the year 1997 but eventually had to postpone it due to budgetary reasons (The Court of the First Instance of the European Communities 1999, 1250f.). In 1995/6 the International Iron and Steel Institute (IISI), now rebranded as the World Steel Association, published its first LCIs (World Steel Association 2011, 85). In 1997 the first elaboration of a BREF for Iron and Steel began (Schoenberger 2009, 1529).

In the cases of the glass (The European Container Glass Federation 2010) and the chlor-alkali industry (Euro Chlor 2013), the present author could not detect

(see also IChemE 2018). Here, an organisation, which is affiliated with an LCA producing European-level paper-related trade association, is also active in providing feedback on IPPC developments.

31“The work carried out under the programme culminated in a conference in January 1996...” (emphasis added) (The Court of the First Instance of the European Communities 1999, 1250).
such a temporal coincidence.

### A.12. Comparison of references to IPPC and EPA in GaBi and Ecoinvent

<table>
<thead>
<tr>
<th>Material</th>
<th>Ecoinvent Description</th>
<th>GaBi Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brass and Bronze</td>
<td>Theoretical modelling of contouring processes based on IPPC (Classen et al. 2009, 822)</td>
<td>EU-28 inventory based on IPPC, Thinkstep, U.S. Geological Survey, World Mine Cost Data Exchange (2017, ID: ac2760c3-78b6-479c-8adf-fd933ae33f1)</td>
</tr>
<tr>
<td>Ceramics</td>
<td>Process description and dust emission from grinding of the raw materials for tiles mainly based on EPA (Kellenberger et al. 2007, 204)</td>
<td>?</td>
</tr>
<tr>
<td>Clay</td>
<td>System characterisation for clay products and processes adapted from EPA (Kellenberger et al. 2007, 158)</td>
<td>For EU-27 clay production self-reference and literature (2016, ID: 1ff9613a-d593-4004-8042-ea632379d8f5)</td>
</tr>
<tr>
<td>Clinker / cement</td>
<td>Clinker inventory based on EPA and EMPA (Kellenberger et al. 2007, 54)</td>
<td>Portland cement inventory for EU-28 based on literature and industry data from German-speaking countries (2017, ID: 6f60ced6-21c8-48b6-ba62-7d078617d0d0)</td>
</tr>
</tbody>
</table>
### Appendix

<table>
<thead>
<tr>
<th>Material</th>
<th>Ecoinvent</th>
<th>GaBi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copper</td>
<td>Inventory is mainly based on German Federal Institute for Geosciences and Natural Resources, also on IPPC, EEA and literature (Classen et al. 2009, 166)</td>
<td>Global copper mix inventory based on IPPC, literature and industry sources (2017, ID: 301d375b-4f27-43f2-bbe0-89f87cae0df1)</td>
</tr>
<tr>
<td>Ferrochromium</td>
<td>Inventory based mainly on German Federal Institute for Geosciences and Natural Resources, also on IPPC, EPA, U.S. Geological Survey, EEA (Classen et al. 2009, 338, 359)</td>
<td>?</td>
</tr>
<tr>
<td>Ferromanganese</td>
<td>Inventory mainly based on German Federal Institute for Geosciences and Natural Resources, also IPPC, EPA and literature (Classen et al. 2009, 377/398)</td>
<td>?</td>
</tr>
<tr>
<td>Fibre glass /</td>
<td>Fibre glass inventory mostly based on IPPC (Kellenberger et al. 2007, 399f.)</td>
<td>For EU-28 glass wool: literature and self-reference (2017, ID: 898618b8-3306-11dd-bd11-0800200c9a66)</td>
</tr>
<tr>
<td>glass wool</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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A.12. Comparison of references to IPPC and EPA in GaBi and Ecoinvent

<table>
<thead>
<tr>
<th>Material</th>
<th>Ecoinvent</th>
<th>GaBi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass (flat glass)</td>
<td>Inventory mostly based on IPPC, some EPA data (Kellenberger et al. 2007, 334/344/360)</td>
<td>EU-28 inventory based on IPPC (2017, ID: ef46d6dc-3834-40b4-8bec-839716ade90d)</td>
</tr>
<tr>
<td>Iron</td>
<td>Blast furnace process: pig iron / hot metal production mainly based on IPPC and German Federal Institute for Geosciences and Natural Resources (Classen et al. 2009, 108)</td>
<td>?</td>
</tr>
<tr>
<td>Lead</td>
<td>Inventory based on IPPC, EEA and literature (Classen et al. 2009, 449)</td>
<td>EU-27 inventory is based on industry data and self-reference (2017, ID: 137f2286-e426-4231-b65d-e65503fa6e5c)</td>
</tr>
<tr>
<td>Lime</td>
<td>Limestone preparation data and emission factors for dust from the crushing, screening and transporting in lime manufacturing are taken from EPA (Kellenberger et al. 2007, 243)</td>
<td>Lime grinding data for Germany from literature (2016, ID: 07462f79-2d70-4b84-94fa-53fccc84bf9b)</td>
</tr>
</tbody>
</table>
## A. Appendices

<table>
<thead>
<tr>
<th>Material</th>
<th>Ecoinvent</th>
<th>GaBi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mineral wool</td>
<td>Allocation of dust to different categories of particulate sizes is based on EPA (Kellenberger et al. 2007, 441)</td>
<td>EU-28 mineral wool data for facades from Rockwool and Saint-Gobain declarations, self-reference (2017, ID: 807701ad-a780-4a46-a378-16d3b3296b8)</td>
</tr>
<tr>
<td>Natural stone plates or slabs</td>
<td>The share of the dust emission categories for natural stone plates is based on EPA data (Kellenberger et al. 2007, 731)</td>
<td>German inventory for natural stone slab based on self-reference and personal communication (2017, ID: 6ac4caff-fb75-4ef2-9041-bc16ee2914d3)</td>
</tr>
<tr>
<td>Nickel</td>
<td>Inventory mainly based on German Federal Institute for Geosciences and Natural Resources and IPPC</td>
<td>Global nickel inventory based on IPPC and literature (2017, ID: 87b2bb39-ff19-427e-a6a2-68a870fceb6)</td>
</tr>
<tr>
<td>Platinum-group metals</td>
<td>Inventory based mainly Öko-Institut and IPPC (Classen et al. 2009, 288)</td>
<td>Global platinum mix inventory based on IPPC, literature and industry data (2017, ID: aafedc51-7444-40b8-bb6d-1fe4ba60106e)</td>
</tr>
<tr>
<td>Rock crushing / crushed rock</td>
<td>The particulate matter (PM10) emissions factor for rock crushing is taken from EPA (Kellenberger et al. 2007, 576)</td>
<td>German inventory based on literature and self-reference (2017, ID: c0d7e4b3-bb1d-4576-80d3-87920ea72f65)</td>
</tr>
<tr>
<td>Material</td>
<td>Ecoinvent</td>
<td>GaBi</td>
</tr>
<tr>
<td>---------------</td>
<td>-----------------------------------------------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>Roof tile</td>
<td>Inventory mainly based on EPA, tile industry of German-speaking countries, Swiss Federal Office of Energy, ETH Zürich (Kellenberger et al. 2007, 173)</td>
<td>German inventory based on company declaration and self-reference (2017, ID: 6048d43a-c429-4545-81de-caddb245e080)</td>
</tr>
<tr>
<td>Steel</td>
<td>Inventory mainly based on IPPC, (Classen et al. 2009, 82)</td>
<td>Data for EAF stainless steel slabs and for representing German situation based on IPPC, ThyssenKrupp and literature (2017, ID: fd0d1461-cb92-437e-a200-b6273654a7bc &amp; a399dc87-a50a-4b5a-a71c-9cddf33f8aa5)</td>
</tr>
<tr>
<td>Tin</td>
<td>Inventory relies largely on IPPC data (Kellenberger et al. 2007, 811)</td>
<td>Global inventory based on IPPC and literature (2017, ID: cd01e11a-8582-4e67-9a3c-f49192def753)</td>
</tr>
<tr>
<td>Vermiculite</td>
<td>Inventory is mainly based on EPA and EMPA (Kellenberger et al. 2007, 695)</td>
<td>?</td>
</tr>
<tr>
<td>Zinc</td>
<td>Inventory based on IPPC, EEA and literature (Classen et al. 2009, 465)</td>
<td>Global zinc sheet inventory is based on US Life Cycle Inventory (USLCI) Library, for which Thinkstep, in its former incarnation of PE International, had gathered industry data (2017, ID: 0f18b2b6-eb10-4b1f-a90a-857351df98b7)</td>
</tr>
</tbody>
</table>
A. Appendices

<table>
<thead>
<tr>
<th>Material</th>
<th>Ecoinvent</th>
<th>GaBi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zinc coating</td>
<td>Inventory based on IPPC</td>
<td>?</td>
</tr>
<tr>
<td></td>
<td>(Classen et al. 2009, 831f.)</td>
<td></td>
</tr>
</tbody>
</table>

A.13. Web of Science Tables

A.14. Data protection

This project is covered by the UCL Data Protection Registration, reference No Z6364106/2015/03/136, section 19, research.
Word count including appendices

Word count: 129,377