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Consumption-oriented policy instruments for fostering greenhouse gas mitigation

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ABSTRACT

Most policy instruments to reduce greenhouse gas (GHG) emissions have focused on producers, and on the energy efficiency of buildings, vehicles and other products. Behavioural changes related to climate change also impact 'in-use' emissions, and potentially, emissions both 'upstream' (including from imported goods) and 'downstream' (eg disposal). Consumption-oriented policies may provide avenues to additional and cost-effective emission reductions, but are less prevalent, in part because of political sensitivities around government efforts to shape individual-level mitigation behaviour. In this paper, we explore policy instruments for encouraging low carbon behaviour in the EU context. Drawing on a literature survey and interviews, as part of the EU Carbon-CAP project, we develop a list of 33 potential instruments, present a systematic methodology for assessing their potential impact and feasibility, and apply this to rank instruments of most interest. Most instruments involve a clear trade-off between their potential impact and feasibility; about half feature in the top three scoring categories, many being voluntary approaches, which may be easier to implement, but with limited or highly uncertain impact. However, we identify a handful of top-scoring instruments that deserve far more policy attention. The complexity of consumer and corporate motivations and behaviours suggests that instruments should be trialled and monitored (e.g. in regions / individual States) before widespread introduction. Most would also be most effective when nested within wider policy packages, to address the varied behavioural motivations and stages of supply chains.

Key policy insights

- Influencing consumer behaviour has been little used in climate policy and is politically sensitive and complex, but can address emissions that have largely escaped influence to date.
- A few instruments stand out as particularly promising, including: technology lists; supply chain procurement by leading retail companies; a carbon-intensive materials consumption charge; and key infrastructure improvements.
- A common trade-off between potential impact and likely feasibility points to the importance of government-business collaboration to secure support and impact.
- More ambitious transformation would require a mix of production and consumption-oriented policy instruments.

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1. Introduction

The potential to reduce greenhouse gas (GHG) emissions through altering behaviour and patterns of consumption has gained increasing attention in recent years (Capstick, Lorenzoni, Corner, & Whitmarsh, 2014; Creutzig et al., 2016; Schanes, Giljum, & Hertwich, 2016). In one of the most extensive and comprehensive studies to date, Moran et al. (2018) estimate that opportunities from changes in consumer behaviour could reduce the EU's overall carbon footprint by about 25%.

This reflects the fact that, as well as the emissions directly involved in individual behaviour (like driving, or heating and cooling), less obvious changes in products and behaviours potentially can affect emissions both 'upstream' (e.g. from the activities that produce consumer goods) and 'downstream' (e.g. arising from waste disposal), as well as 'in-use' behaviours. This also means that, unlike more traditional policies focused upon production choices and product energy efficiency, changes in behaviour can impact the emissions 'embodied' not only from domestic production but in internationally traded products[1].

The relative significance of embodied emissions in global decarbonization efforts is rising as traditional policies improve domestic energy efficiency and decarbonize electricity generation over time. Some studies indicate that the emissions associated with constructing a highly efficient building (including the materials) may approach (Eaton & Amato, 2005; Engin & Frances, 2010) or even exceed (Ibn-Mohammed et al., 2013) Huberman & Pearlmutter, 2008) its subsequent 'in-use' emissions. Similarly, Ma, Balthasar, Tait, Riera-Palou, and Harrison (2012) find the relative share of manufacturing and operational CO_2 emissions for electric vehicles to be roughly equal under a projected average UK electricity mix. Deep decarbonization is inconceivable without attention to the roles of individual and corporate mitigation behaviour and embodied emissions.

This article explores consumption–oriented policy, which we define as actions by governments or business to change consumer behaviour, that goes beyond the mere purchases of products or services based on traditional economic considerations, but also includes 'embodied' emissions, and the use and /or disposal phase. Note that such policy instruments may directly target individual behaviour, or instead engage the retail companies that market goods to consumers, hence may be directly consumer-based, or retailer-based, and may also influence intermediate (materials) consumption choices of industries in supply chains.

Whilst clearly deserving of urgent attention, consumer-based policy faces a number of inherent challenges in its design and implementation. One challenge is the political risk associated with targeting private behaviour, in terms of perceived encroachment on individual decision-making (i.e. 'telling people how to behave'), increased public visibility and hence potential for controversy, and the contention associated with placing responsibility of climate action on individual instead of corporate actors (Schanes, Jäger, & Drummond, 2019). Another difficulty, facing all consumption-oriented policy, lies in the unpredictability of behavioural responses and therefore policy effectiveness. Individual behaviours and social practices are shaped by complex sociocultural, technical and institutional structures – a 'web of constraints' – a lack of understanding of which can critically impede policy effectiveness (Ekins, Domenech, & Drummond, 2019; Grubb, Hourcade, & Neuhoff, 2014; Hobson, 2002; Røpke, 2009; Shove, 2010).

There have, however, been some noteworthy advances in consumption-oriented policy in recent years. Drawing on research across sociology, psychology, economics, as well as trial and error experience, some promising policy options have emerged, along with lessons for their effective implementation (e.g. Reisch & Zhao, 2017). The alignment of reduced consumption with other goals, such as health and lower household expenditure, appears particularly effective as a driver of change. Moreover, significant complementarity with production-based policies can be achieved by targeting hard-to-reach emission sources such as industrial processes that are difficult or expensive to clean up (Bataille et al., 2018). Indeed, many of the options identified by Moran et al. (2018) are beyond the reach of traditional production-and-product oriented policies. Nonetheless, identifying the potential associated with consumer mitigation behaviours-is only one step. A lack of clarity around the options for intervention available to policymakers, and crucially the relative promise of these options in terms of impact and feasibility, impedes progress in consumption-oriented policy.

This article seeks to assess the *policy instruments* that might encourage consumption changes. Specifically, we aim to gain a better understanding of the consumption-oriented policy instruments available, where they might be applied, the obstacles that may hamper their implementation, and their effectiveness if implemented. Our research objective was addressed through three steps:

- Developing a *long list* of policy instruments that could influence the adoption of low carbon behaviour, based on a review of the literature and interviews with representatives of the supply, consumption and use chains of the major product categories considered (building materials, transport, food, white goods, paper/cloth, electronic goods and lighting);
- Designing a novel *evaluation framework* for assessing the potential impact, attractiveness and political feasibility of such policy instruments, employing high-level results from Multi-Regional Input-Output (MRIO) analysis, empirical studies of consumer response to past policies, and expert judgement drawing on the above-mentioned interviews;
- Applying this evaluation framework to our list of policy instruments so as to offer a *ranking of policy instruments* that deserve closer scrutiny in climate policy debates, supplemented by the informed judgements of the research team.

Our research covers a broad range of sectors, with particular attention to buildings, transport and food, which Moran et al. (2018) find account for 24%, 39%, and 26% respectively of the total emissions reduction potential from EU consumption changes (see also Wood et al., 2019). Our supporting Supplemental Material (SM) summarizes application of our analysis by sector.

The scope and potential additionality of consumption-oriented policies is illustrated in Figure 1. Energy-climate policy has traditionally focused mainly on production activities, with consumption addressed principally in terms of the energy efficiency of products. Consumption-oriented policy offers indirect ways to address the energy-related emissions 'embedded' in making products – whether at home or abroad – along with use and disposal practices. An important motivation is that such policy may enhance the scope of impact compared to more traditional climate policies.

To help increase the specificity of our analysis and to link better to the EU-focused quantitative studies in the EU Carbon-CAP[2] project from which this paper is derived (Moran et al., 2018; Wood et al., 2019), we focus our research at the EU level. As well as reflecting the expertise of the authors, the EU is a major consuming region, with live debate about its 'carbon footprint', and with a complex multi-level policy structure. It is also a region with comparatively well established 'traditional' climate policies, seeking additional options to deliver greater ambition. However, we believe the approaches and insights discussed in this paper could be applicable to the challenges of promoting consumption-based GHG emission reductions more widely.

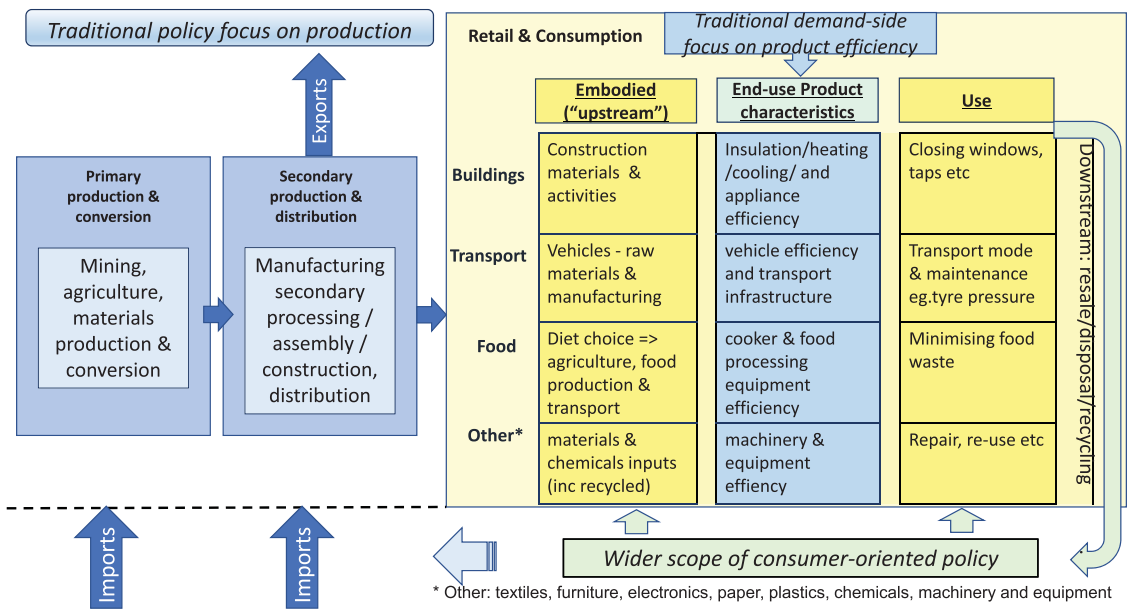

Figure 1. Sectors and scope of consumption-oriented policy contrasted with traditional production focus of climate mitigation policies.

The remainder of this paper is structured as follows. Section 2 identifies the long-list of consumption-oriented policy instruments and outlines their development. Section 3 explains the multi-criteria policy evaluation framework, including how the criteria were developed, and the ranking and aggregation of policy instruments. Section 4 presents and discusses the results, Section 4 offers some sectoral observations, and finally Section 6 concludes.

2. Developing a long list of policy instruments and their influence

As the initial step to identifying a list of policy instruments for analysis and their various points of intervention, a literature review was conducted, which resulted in an initial pool of 28 policy instruments (for main sources, see SM). We considered both policy instruments targeted at consumers directly and at consumer-facing retailers (whilst acknowledging their interactions). Interviews were then carried out with representatives of 42 organizations, most of whom were participating in an international, business-led, carbon reduction framework being developed by the Corporate Leaders programme of the Cambridge Institute for Sustainability Leadership (36 businesses), supplemented by NGOs (4) and consumer representation organizations (2). These organizations have global reach, and hence deal with supply chains that are both EU and non-EU. Participants included representatives from food, transport, buildings and 'general consumer goods' (largely retail stores).

Each was asked to reflect on the initial list of potential policy instruments prior to their interview including the key actors targeted (intermediate / retail organization, or final consumer), and to suggest any instruments that might be missing. They considered both public policies and policies adopted internally by industries, such as voluntary product labels or industry standards. Along with input from research colleagues, this expanded the pool of potential policy instruments from an initial list of 28 to a final list of 33 (see Table 1), mostly through mention of instruments arising from the retail community such as voluntary industry standards.[3] These interviews also helped to clarify our rankings of potential impact, as described below.

A key result of the interviews was the consistent focus on the role of intermediaries, such as retailers or estate agents, in shaping the behaviours of consumers. There was broad recognition that consumers might be influenced, or 'nudged', by intermediaries at any of several stages in the process of purchasing and using a product. These included potential interventions in (i) the range of products offered for sale, (ii) the location of those products in a retail store, (iii) the pricing of those products, and (iv) the information provided to consumers either in-store or by advertising. These various points of intervention might in turn affect which product a consumer purchases and/or its quantity (i.e. changes in demand for a consumer category). As a result, interviewees considered policy instruments that might influence the consumer at any of these steps, resulting in instruments that focus either on the intermediary (such as affecting the range of products offered), the consumer (such as information on carbon content), or both, through a more generalized signal such as a carbon price where the market would sort out which group was most affected.

Table 1 sets out the final long list of assessed policy instruments, classified according to the type of instrument. It provides a brief description of each, and indicates whether it primarily targets consumers or retailers (or other intermediaries).

For organizational and presentational purposes, we classified the policy instruments into groups of more manageable size drawing on an underlying economic logic.2F[4] These comprise instruments focused on *information;* more directly *regulatory* and *administrative* tools; *economic* instruments associated with classical price-based behaviour, and *enabling* instruments such as infrastructure, that are most potentially relevant to more strategic transformations. The policy instruments and their potential application in the key sectors are described more fully in the SM, which adds a further distinction between policy instruments likely to be mandatory, and those more suited to voluntary adoption.

3. Multi-criteria policy evaluation framework

With such a plethora of policy instruments applicable to several different actors or stages in the supply chain, a key challenge was to establish criteria and methods for the evaluation of these instruments suited to ranking. The nature of this multi-attribute evaluation challenge with the common objective of GHG reduction is one of

Table 1. The long list of consumption-oriented policy instruments.

Policy Instrument	Summary	Main target (R = retailer; C = consumer)
Information instruments		
Product labels	Requirement of embodied and/or likely in-use energy / carbon information on labels	R, C
Approved technology lists	List of e.g. 'efficient technologies' approved by a public authority for sale or procurement	R, C
Graduated tax on advertising	Tax on advertising that increases with carbon content of a product or service	C
Information campaign	Information provision to potential consumers regarding carbon implications of consumption patterns	C
Product location at sale	Low carbon products are given preferential placement at retail stores, internet sites, etc.	C
Rankings and Award campaigns	Product manufacturers and/or sellers are given publicly celebrated awards for low carbon performance	R
Regulatory and Administrative instruments		
Regulatory standards	Direct regulation of performance of products available at point of sale	R
Licenses	License is required either to sell or purchase high carbon products	R
Government procurement	Government gives preferential procurement to low carbon options	R
Recycling requirements	Retailer and/or consumers have responsibility for recycling product, with a ban on landfilling	R, C
Product ban	Products banned based on criterion of embodied carbon and/or likely energy/carbon (in)efficiency in use	R
Waste targets, requirements and/or prices*	Product recycling is motivated through waste policies	C
Deposits / refunds on purchased goods	Deposits are initiated to enhance recycling of goods to reduce raw materials requirements	C
Limits on ownership or use	Restrictions on the number of a given product (such as cars) that can be purchased and/or owned.	C
Sector trade body standards	Voluntary product performance standards set by trade organizations	R
Business emission agreements / allowances*	Businesses (e.g. retail) have goal for emissions; mandatory variant requires legal allowances, with trading	R
Supply chain procurement requirements	Retailers establish embodied carbon requirements on intermediate producers	R
Voluntary agreements by trade organizations	Trade organizations adopt voluntary commitments to reduce embodied and/or in-use CO2	R
Extension of product lifetime	Restrictions on the practice of planned obsolescence, or requirements of product lifespan	C
Shop product choice	Point of sale operators voluntarily restrict products to lower embodied and/or more energy/carbon efficient models	R
Economic instruments		
Carbon-intensive materials charge	Duty attached to product on grounds of typically high energy/carbon intensity (e.g. through benchmark)	R, C
Carbon embodied charge	Charge levied on basis of actual emissions in making and delivering the product	C
Product user fees	A fee is attached at point of sale based on carbon associated with subsequent use	C
Waste and recycling – financial*	*See Administrative*	
Minimum price limits	Very low prices are banned to remove from markets products that have less incorporation of externalities	R, C
Business emission allowances*	See SM and note 10	
Subsidy	Government or trade subsidy of low carbon products	R, C
Product tax incentives	e.g. Enhanced tax depreciation based on product performance / embodied carbon	R
Trade Environmental Goods and Services agreements – e.g. tariffs	Proposal for tariff reductions on EGS products	R
Preferential finance terms	Lower interest rates for low carbon investments (e.g. energy efficiency improvements in buildings)	C
Enabling instruments		
Mandatory metering	Requirement of metering for power and gas use in buildings to signal energy consumption	C
Infrastructure improvements	Improvements to infrastructure that enable low carbon options (e.g. public transport)	C

(*Continued*)

Table 1. Continued.

Policy Instrument	Summary	Main target (R = retailer; C = consumer)
Enabling recycling	Creation of the infrastructure for recycling of goods between consumers	C
Enabling product sharing	Creating infrastructure for shared ownership and/or use of products (e.g. Zipcar)	C

*These policy instruments may be applied in different forms and may therefore appear in more than one category

multi-criteria decision analysis (MCDA) (Belton & Stewart, 2002). A useful broad review of this approach with reference to energy is given by Wang, Jing, Zhang, and Zhao (2009); applications to sustainable energy planning are reviewed by Pohekar and Ramachandran (2004), whilst Mendoza and Martins (2006) consider more broadly applications to natural resource management, and in particular forestry. Following standard MCDA practice, the process of evaluation breaks down into the following constituent parts:

- Selection of evaluation criteria
- Selection of the scoring system that is used for each individual criterion
- Combination of scoring results of the different criteria into a summary measure of the 'potential significance' of a given policy instrument

Derived partly from general principles of policy evaluation also developed and applied to climate policy in Aldy, Barrett, and Stavins (2003), six criteria for policy instrument evaluation were used. Two of these concerned the *potential impact* of the policy instrument if it was introduced throughout an entire sector (food, transport etc.):

Policy scope. This reflects the percentage of EU carbon emissions associated with a given sector targeted by a policy instrument. As a starting point, the MRIO model results developed by Skelton, Guan, Peters, and Crawford-Brown (2011) for the EU were used to assign these percentages.

Likely effectiveness. This combines an estimate of the percentage reduction in emissions from a given sector *if all actors in the sector implemented the policy instrument*, multiplied by the *fraction of actors plausibly implementing the policy instrument* by effecting the changes intended by the instrument (the 'uptake rate'). Where available, the former was taken from a review of the emissions reductions in the past when specific policy instruments were applied and the latter estimated from literature review of past uptake rates (Crawford-Brown, Skelton, & Grubb, 2014) with additional input from a survey of a sample of 15 actors in each target sector (Crawford-Brown et al., 2015). As in the development of the initial policy instrument list, the survey of actors consisted largely of representatives of affected consumer-facing industries – mostly retail (31), as well as NGOs (4) and consumer representation organisations (2) - again spread across the sectors.

The other four criteria concern the *likely feasibility* of the policy instrument being applied in the first place. We drew on expertise across the authors and the wider Carbon-CAP research consortium to evaluate the policy instruments against the following feasibility criteria, primarily through a review of literature and expert judgement3F[5]:

Domestic political feasibility - distribution and flexibility. Both international and domestic distributional economic impacts affect political feasibility. These effects were primarily judged at sector level; cost-raising impacts of policies have different equity impacts for different sectors, whereby impacts on food and energy prices raise the strongest concerns. Flexibility is relevant insofar as a flexible policy instrument is likely to have many more ways to adjust to ameliorate potential distributional impacts.

Legal feasibility. Legal feasibility seems curiously absent from many MCDA frameworks. However, it is in fact a crucial factor, particularly for policy instruments directly concerning consumption, which may have implications for trade and for individual consumer rights, constrained both by the structures of EU law and international trade law. This criterion thus considers the EU and international legal dimensions that might pose challenges to a policy instrument and hence delay or prevent implementation.

International political feasibility. This considers international spill-over effects (e.g. on trade flows and market access), and hence whether international repercussions might constrain the ability of EU or Member States to implement a given

instrument. This is different from the legal feasibility assessment, since an instrument that may be legally feasible may still be provocative from a political point of view and could lead to international tensions that may render it difficult to implement. For example, while the EU's attempt to include aviation in the EU ETS may have been legal under WTO law, it nevertheless raised a storm of opposition because of the appearance of extra-territoriality and feared impacts on small island states, and thus has so far proved impractical to implement.

EU Administrative and Institutional Feasibility. This criterion sought to assess the administrative and institutional complexities of applying a given policy instrument. For example, in some cases, the data and/or enforcement requirements might make a policy instrument impractical, or institutional relationships between the European Commission (EC) and Member States might also pose major obstacles.

3.1. Criteria ranking system

Each policy instrument was given a rating of 1, 2 or 3 on each criterion, where 1 is the least favourable and 3 is the most favourable.[6] The more common approach in MCDA of using a 1-10 scale was far too granular for our subjective and mixed qualitative-quantitative approach.

For *potential impact* criteria (consisting of scope and effectiveness), the result of Skelton et al.'s (2011) MRIO analysis was summarized as a percentage of carbon emissions embodied in EU consumption. This was then multiplied by a judgement of the likely uptake rate in each of the product category sectors, given as the fraction of actors in a sector estimated to respond to the policy instrument multiplied by their fractional carbon reduction. Potential impact ratings were then assigned as 1-low (the instrument, adopted in full, is likely to yield less than a 10% reduction in CO_2 associated with demand for the product/service category); 2-medium (10–30% reduction); and 3-high (>30% reduction).

For *feasibility* criteria, a similar system with ratings of 1, 2 or 3 was developed, where 1 is the least favourable (implying a major barrier / challenge) and 3 is the most favourable (the policy instrument is unlikely to face a significant challenge). A rating of 2 applies where there is a challenge, but one that seems reasonably surmountable (e.g. has been successfully ameliorated in past policies). A rating of 0 was made available to indicate where a policy instrument is fundamentally impractical. The *specific* interpretation of the 1, 2 and 3 ratings for each criterion and product sector are indicated in Grubb et al. (2015).

Our core analysis did not apply any criteria weighting, though this implicitly assigns feasibility greater significance than potential impact, with four and two associated criteria respectively. This risks screening out potentially highly impactful instruments that are difficult to implement. Since policy-making institutions will have their own views on feasibility, we also performed a sensitivity analysis in which we assigned feasibility criteria a lower weighting of 0.5, such that in aggregate they were weighted equally with impact criteria. These results are also indicated with the main results (Table 3), which shows in bold the instruments whose ranking was robust (or higher in relative terms) with respect to this sensitivity.

3.2 Aggregation and presentation

Aggregation of scoring results into a single compound indicator of desirability is typically achieved through either an additive or multiplicative approach in MCDA (Wang et al., 2009). We considered that addition would not reflect the reality that, in order to be worth serious consideration, a policy instrument must be at least somewhat plausible on all criteria. Very low ratings (1) on any criteria should raise warning flags and merit serious specific consideration to see if challenges can be overcome – it is not something that could be just eclipsed by high ratings on other criteria. In extreme cases, if a policy instrument would have no impact, or is politically and legally clearly infeasible (meriting a rating of 0), it can be discarded. The policy challenge is essentially combinatorial across the multiple potential challenges, not additive.

Consequently, a multiplicative aggregation of the results was selected, to yield a *compound* of the individual criteria scores (Equation 1):[7]

$$\text{Compound score} = \frac{\prod_{n=1}^{N=6} s_n}{N} \tag{1}$$

where s indicates the assigned score, taking a value from 1–3, n_s refers to the number of criteria allocated with score s, and N gives the total number of criteria, which in our case was 6. Table 2 gives the resulting compound scores that were assigned to each policy instrument.

As indicated in Table 2, we assign an overall policy instrument ranking, indicating the priority for more detailed consideration of a policy instrument for implementation. The rest of this paper presents the results. The compound scores by policy instrument and sector are tabulated in the Annex; the SM tabulates the component ratings with explanation and sources, drawing on Grubb et al. (2015).

4. Results

Table 3 summarizes the results in terms of the top three policy instrument rankings (compound scores as indicated in Table 2, achieved for at least two sectors). In total these cover about half of all the instruments evaluated and as given in Table 1. The first column shows the policy instrument; the second, the product sectors in which the compound scores were highest; and the final column shows the criteria and/or associated sectors for which the policy instrument scores most poorly. This gives an indication of where the biggest challenges lie.

4.1. Top-ranking policy instruments

Approved technology lists (SM #2) and **supply chain procurement** (SM #16) policy instruments score high across a wide range of sectors. This reflects evidence of both high potential effectiveness with generally high feasibility, based on clear examples.[8] The main doubts or constraints on both of these (i.e. criteria given a score of 2 rather than 3) reflect similar concerns: applications may be limited in scope, and the implication of recommending or choosing some technologies (and hence implicitly some companies and/or countries) over others could raise political complexities and potential resistance (particularly international).

The **carbon-intensive materials charge** (SM #20) scores equally highly in aggregate, because of its potential to operate across supply chains into multiple end-sectors, facing minimal legal obstacles – analogous to fuel excise or alcohol duties – which also eases implementation, at least in principle. Separate modelling analysis (Pollitt, Lin, & Neuhoff, 2019) suggests this could reduce emissions by up to 10%, a very large impact compared to most individual policies, partly because, being applied at the intermediate consumption (materials) stage, it covers many end-use sectors. The areas of challenge concern its impact on final consumer behaviour (i.e. the cost may be too diluted at the point of consumption) and complexity of its implementation.[9]

Table 2. Policy instrument scoring aggregation.

No. of '3' scores	No. of '2' scores	No. of '1' scores	Compound score	
6	0	0	122*	
5	1	0	81*	1st Rank*
4	2	0	54	
5	0	1	41	
3	3	0	36	2nd Rank
4	1	1	27	
2	4	0	24	3rd Rank
3	2	1	18	
1	5	0	16	

* in practice no instrument scored above 54

Table 3. Potential significance of consumption-oriented policy instruments by compound rank, key sectors and limiting criteria.

Policy instrument	Key sectors	Lower criteria scores*
First Rank (compound score > 50)		
Approved technology lists	All score 54 except food, heat & electricity sourcing (36)	Scope; International political
Supply chain procurement	All score 54 except food, heat & electricity sourcing (36)	Scope; International political
Carbon-intensive materials charge	Building fabric / consumer goods & machinery / paper & plastics / vehicles	Effectiveness; EU Admin & Implementation
Infrastructure improvement	Transport vehicles & fuels / building fabrics	Scope; distributional
Retailers product choice	Food / buildings fabric / consumer goods & machinery / textiles	Scope & effectiveness
Product location at sale	Food & textiles	Scope & effectiveness
Second Rank (compound score 31–50)		
Regulatory Standards	Buildings fabric / consumer goods & machinery	Legal; International political
Business emission agreements or allowances	Buildings / paper & plastics / consumer goods & machinery	Scope & Effectiveness; EU Admin & Implementation
Environmental Goods and Services (Trade) Agreements	Building fabric / consumer goods & machinery / paper & plastics / vehicles	Scope & Effectiveness; EU Admin & Implementation
Recycling requirements & waste targets / prices	Buildings fabric / paper & plastics / consumer goods & machinery	Scope & Effectiveness; EU Admin & Implementation
Voluntary agreements by trade associations	Vehicles incl. fuels / consumer goods & machinery	Effectiveness (1)
Third Rank (compound score 20–30)		
Government procurement	All sectors	Legal; International political
Information Campaigns	Building fabric / consumer goods & machinery / paper & plastics / vehicles	Scope & Effectiveness; EU Admin & Implementation
Ranking and award campaigns	Buildings fabric / paper & plastics / consumer goods & machinery	Scope & Effectiveness; EU Admin & Implementation
Sector trade body standards & voluntary agreements	Vehicles/ fuels/ consumer goods & machinery	Effectiveness (1);
Minimum price limits	Buildings fabric/ paper & plastics / consumer goods & machinery /	Scope & Effectiveness; EU Admin & Implementation
Product user fees	Buildings fabric / consumer goods & machinery /	Key sectors in Scope (1); distribution and flexibility (1)
Deposit / refunds	Textiles / consumer goods & machinery / maybe vehicles & food	Scope (1) across all sectors
Preferential finance terms	Vehicles / consumer goods and machinery	*Distribution* & *flexibility* (1) in direct consumption (food, elec. & gas) & *effectiveness (1) for* paper &plastics, textiles
Enabling product sharing	Vehicles	Effectiveness (1) for all sectors outside transport; also distributional concerns in direct consumption

Notes: **Bold** indicates that ranking is robust against a sensitivity study of reduced weights on feasibility criteria.
Italic Indicates where design choices could enhance effectiveness (eg mandatory forms of business emission allowances, as note 10)
*'(1)' indicates this criterion was scored 1 indicating a low potential impact or feasibility on this criterion.

Infrastructure improvements (SM #31) also score highly for transport vehicles and fuels, and also building fabric. The potential limitations are seen to be in its scope, and other concerns over feasibility, which vary significantly by sector.

Finally, in some key sectors, voluntary consumer-facing choices at the retail level appear important. Store retailers inevitably exercise 'choice editing' as they select which products to put on sale, and including GHG criteria in **retailers' product choice** (SM #19) could have significant impact. The possible role of *specialist* retailers' product choice – who only stock low-carbon products, and energy suppliers who only supply green electricity – forms a special case of this. In addition, retailers know the power of product placement in stores (some supply companies already pay stores for preferential placement) so **preferential point-of-sale location for low-carbon products** (SM #5) also features, though *only for food and textiles.* However, these voluntary policy instruments score lower on the criterion of effectiveness because of doubts about impact related to market pressures discouraging retailers from refusing to stock higher carbon footprint products, and the realistic scope of application and effectiveness of product location in bringing about large-scale change in consumer behaviour.

4.2. Second-ranking policy instruments

Of the five policy instruments within the second ranking indicated, only **regulatory standards** (SM #7) are robust on the compound score across sectors. The others all suffer for remarkably similar reasons, namely doubts about their potential impact (scope and effectiveness), along with concerns about the feasibility of effective administration and implementation in the EU. Evaluation of **business emission agreements or allowances** proved particularly problematic because of the range of forms this could take, including mandatory vs. voluntary variants.[10] The easier, voluntary approaches were deemed likely to have far less impact based on low anticipated uptake rate by retailers. The impact of the Environmental Goods Agreement, currently being negotiated, was also estimated as quite limited, but extending its scope into to a full **Environmental Goods and Services Trade Agreement (SM #27)** could substantially enhance impact.

The modest scoring of **recycling & waste requirements** (SM #10, #12) reflects in part the difficulties experienced with implementing legislation in this area (e.g. across different parts of the EU). However, these may gain greater impact in the wider context of increasing emphasis on a 'circular economy' in scientific analysis (resource potentials) and public acceptance (e.g. discussion on plastic waste), combined with corporate-focused policies of Extended Producer Responsibility (see for example Rizos, Behrens, Drabik, Rinaldi, & Tuokko, 2018).

Finally, **sector trade body standards** (SM #14) generally cannot carry legal force because they apply at sector not company level, so it is unclear which specific companies might be held liable for failure to act.

The tally of eleven policy instruments in the top two tiers gives a good starting point for closer policy consideration. Table 3 adds more in the third ranking, of which the effectiveness of **government procurement** (SM #9) is robust. Despite significant experience and based on some substantial existing literature, this moderate ranking of government procurement as a general policy instrument in the EU reflects concerns about international political reaction to what could be considered akin to 'local content requirements', as well as EU State Aid rules restricting what governments can specify in procurement contracts, which further constrain both the scope and the impact. All four feasibility criteria are therefore evaluated with a score of 2. The EU guidelines on green public procurement and various pilot procurement contracts are gradually removing the legal and administrative obstacles, which could then make public procurement at least as important as the (first-ranked) policy instrument of private sector supply chain procurement. An evaluation published shortly before this article went to press (Hasanbeigi et al., 2019) notes that 'Common voluntary Green Public Procurement criteria have been developed for purchasers in the EU to avoid distortion of the European single market', and notes limited but growing use of such GPP contracts.[11]

Several other policy instruments share this third rank score as indicated, most of which score lower in the sensitivity analysis due to their voluntary nature. This means the relative ease of implementation is offset in part by doubts about their actual impact or the extent of their scope of application as measured by uptake rate. Conversely, as noted in the conclusions, a full **carbon-embodied charge** (SM #21) was graded low due to serious feasibility concerns (notably, scoring a '1' on EU administrative complexity), but – due to its top-scoring potential impact notably on embodied carbon in buildings and vehicles – ranked better on the sensitivity study.

Our analysis also enables a cautious overview by sectors. Table 4 below shows the *average* (mean) scores across *all* assessed policy instruments for each sector/subsector. Vehicles, buildings fabric and consumer goods appear the easiest sectors to influence. Using consumption-based instruments to influence choices on the carbon intensity of fuels (e.g. biofuels, low carbon heating and electricity at scale) seems harder, whilst food, textiles, and paper & plastics generally seem to be the most challenging sectors for consumer-facing climate policies.

It would be dangerous to over-generalise at sector levels. Nevertheless, it is interesting to look through the policy instruments targeting the food sector, where few behavioural change options feature significantly. On the production side, the European agricultural sector is a highly regulated market in which numerous regulatory and market-based policy instruments are already in place. At present, however, consumption-oriented policies mostly target sugar intake and obesity, with few targeting low carbon food consumption behaviour

Table 4. Scores by sector averaged across all instruments.

	Transport			Buildings					
	Vehicles	Fuels	Food	Fabric	Heat	Elec	Paper & plastics	Textiles	Consumer goods & machinery
Average score by sector	25	17	15	30	11	11	20	20	29

(e.g. eating less meat and reducing food waste) that are mainly limited to soft instruments such as awareness campaigns, labelling and information platforms (Schanes et al., 2016). More stringent policies on production (e.g. abolishing subsidies on GHG intensive food, stronger regulations) combined with softer policy instruments might be more effective (Priefer, Jörissen, & Bräutigam, 2016; Schanes, Dobernig & Gözet, 2018) but are politically sensitive. There appears to remain a huge untapped potential that could reduce emissions from the food sector through tackling consumers' food behaviour (see also Reisch, Eberle, & Lorek, 2013), but little empirical evaluation of how to encourage such changes. For food, and to a lesser extent for textiles, and paper & plastics, the significant options emphasize far more voluntary engagement with retailers (such as product placement in stores) and the supply chains of their producers; achieving significant impact would likely require wide-ranging policy packages.

5. Discussion: consumption-based policy in a wider context

As noted, emissions are caused by many different types of decisions at many different levels in the chain of production, sales, purchase, consumption and use/disposal, and consumption-oriented policies only act on part of the whole. Overall, the *transformative* changes implied for deep decarbonization may well need to consider coordinated packages of policy instruments, which combine the most relevant instruments for each sector, including potentially both producers, intermediaries, and final consumers. Consumption-oriented policy should not – and need not – have the effect of wholly 'individualising' responsibility for the environmental crisis solely on end-users; behavioural changes will need to be implemented in concert with pervasive structural changes to make the right choice the easy choice (Clarke, Newman, Smith, Vidler, & Westmarland, 2007; Princen, 2002; Thøgersen, 2005).

Indeed, experience has shown policies are often most effective when developed 'in tandem', in mutually reinforcing ways (Rogge & Reichardt, 2016). Because populations are diverse and markets are dynamic, tools of information, standards and financial incentives have been needed to 'transform' markets of energy efficient goods. Any process of technological diffusion and transformation involves many different stages, moving through different population sectors. Information can particularly engage the market 'leaders', while others might respond more strongly to financial incentives of various forms. 'Laggards' – with old product lines selling to 'disengaged' consumers – may pay attention to neither, but once better alternatives are well established, blunter policy instruments may become more feasible and necessary, in some cases banning an entire class of energy-wasting technology (as with incandescent bulbs)[12].

Thus, consumption-oriented policy instruments appear in direct opposition to the Tinbergen (1956) Rule often cited in economics, that an efficient approach requires one instrument for each objective. This may be true for static problems with clear economic optimality criteria, but neither of these conditions apply concerning policy instruments which seek to influence consumer and corporate behaviour and systems, ultimately towards transformative changes. The uncertainties and limited reach of many individual policy instruments amplifies the need to consider packages of instruments in order to reach different actors within the same overall supply chains, and to provide often mutually reinforcing signals to the market. In most cases, policies that go beyond incentives offer some complementary tools.

Finally, the compound scores are inevitably, in part, a subjective evaluation, albeit with expert judgement guided by objective experience of policy instruments. An important caveat thus stems from the fact that the evaluation is largely static, based on current circumstances and scope. These of course could change over time.

For example, the limited scope of government procurement under EU State Aid rules constrained its score, but is shifting (Hasanbeigi, Becqué, & Springer, 2019) and might still be of wider importance if some legal constraints could be further ameliorated and/or it were able to kick-start more extensive capacity for green buildings in the construction sector.

Another illustration concerns the 'carbon embodied charge', for which the overall score does not place it in the top three tiers, despite it receiving top Impact scores (3 for both scope and effectiveness). Along with mid ranking for its legal and international political complexities, its 'Achille's Heel' is the evaluation that EU implementation would face severe challenges (score 1). Perhaps more than any other policy instrument, this raises the question of how much a specific vision of the administrative details, or technological capability (e.g. Blockchain tracing of carbon through supply chains) or legal and political conditions might change over time. What may seem a huge hurdle to application of a policy instrument at the time of the survey, may

already have changed with the consideration of further implementation options or evolve with new technological perspectives in the future. The results here may thus be interpreted as indicating where effort – legal, economic, policy and political – might be directed in the future if a *potentially* highly impactful policy instrument is to become a more credible part of the policy toolbox.

6. Conclusions

As ambition increases towards 'net zero', policy urgently needs to more systematically consider options to influence consumer mitigation behaviour. However, there are no 'golden bullets' for consumption-oriented policy: if there were, they would doubtless have already been adopted. Our analysis in particular highlights a frequent trade-off between potential impact and political feasibility. Many policy instruments that appear relatively easy to implement are of dubious effectiveness, whilst those that could wield high impact often appear very difficult to implement. Out of our initial list of 33 policy instrument options, we identified just a few instruments that appear to offer a good combination of both. Nevertheless, a range of policy instruments, of varied forms across almost all categories (informational, regulatory, economic, and informational), and across the voluntary / mandatory distinction, have compound scores of potential interest.

As emphasized, the compound score developed here is a guide to where governments might prioritise efforts, it is not determinative. Its components need to be understood before a given policy instrument is prioritized, or rejected, for a particular application, since points of weakness in a compound score might potentially be ameliorated by introduction of packages of mutually supportive policy instruments. Our SM describes the policy instruments, gives references to where their application has been tried and written up, and shows the scoring by sector and criteria used by the project evaluators.

In addition to the often unavoidably part-subjective or context-dependent nature of the evaluation, the relevance of policy instruments may vary with sector applications and design details. To help address this, the Carbon-CAP project established an online tool[13] to enable anyone to see not only the detail of evaluations but to test their own scoring, particularly from sector-specific standpoints, which may often be most relevant to actual public or private sector policymaking.

It remains extremely difficult to quantify the impacts of particular policy instruments, and even more so to estimate the likely response to new policy instruments which seek to change behaviour. There are many cases where hopeful experts and civil servants have advocated new policy instruments, only to find the actual response disappointing – though the converse can also happen (e.g. see example in note 10).

This suggests a strong case for a philosophy of experimentation, with policy instruments trialled for example in cities, or in one subsector, before being rolled out at national level or, in Europe, through EC Directives. An additional motivation for experimentation concerns *process*: whilst not a formal part of our evaluation criteria, our research emphasized that the *process* of policy formation also matters, introducing several additional potential criteria many of which would be most easily met through trialling of policy instruments at smaller scales. Consequently, our methodology and results should rather be considered as a guided menu of consumption-oriented policy instruments, for further exploration and trialling.

Notes

1. The concept of 'imported' emissions associated with international trade (or 'emission transfers') is often conflated with 'embodied' emissions. Embodied emissions are those associated with the production of a product, be it domestic or international, and therefore international 'emission transfers' represent only a portion of overall embodied emissions. The concept of 'carbon footprint' typically conflates domestic emissions along with such imports. Wood et al. (2019) estimate that about a third of the EU's gross GHG footprint is associated with imports, but their sectoral analysis emphasizes that some of this is associated with activities that are hard to abate and cannot relocate, notably mining and agricultural activities abroad. Across all the consumption-oriented measures that Moran et al. (2018) consider to reduce the EU carbon footprint, they estimate that 75% of the savings would be within the EU, the other 25% arising from reduced embodied emission imports, which seems broadly consistent with the implications of the Wood et al. (2019) sectoral analysis.
2. www.carboncap.eu.
3. We decided to exclude 'personal carbon allowances' from our detailed examination, partly because this approach has already received wide attention in literature (e.g. Special Issue: Fawcett and Parag 2010, eds) and politically. This does not constitute any particular view of the research team regarding the overall viability, feasibility or desirability of this approach.

4. Drawing on the broad Three Domains logic of Grubb et al. (2014), consumption behaviour tends to exhibit strong 'first domain' characteristics associated with behavioural and organisational theories. The other two domains reflect respectively classical economic optimizing behaviour ('*homo economicus*'), and strategic decision-making associated in particular with innovation and transformative changes. First domain economics emphasizes the complexity of human behaviours, and finds that effective policy instruments (eg. for energy efficiency) have tended to involve either regulatory approaches (such as standards), or direct engagement (such as providing clear and effective information) to support 'smarter choices'.
5. In each case, the judgement is necessarily subjective, informed by past experiences (some contained in the literature and others in the project team) with problems that can arise in implementing policy instruments and hence delaying their application. Much greater detail on the evidence and analyses for these criteria applied to the specific sectors can be found in the Carbon CAP reports at www.carboncap.eu, mainly Grubb et al. (2015).
6. Where relevant evidence was available from past experience, the result is based on the median value of changes in carbon emissions when a policy is introduced, but these inevitably remain indicative of the relationship between a specific policy instrument and consumption-based carbon emissions reduction. In general, given the inevitable lack of precision and often subjectivity in applying judgements, the choices were restricted to integer values, although exceptions (for example a score of 1.5) were allowed where this was clearly needed to communicate relative rankings in the scoring of a particular criterion applied to different policy instruments.
7. Note that this uses a different and simpler weighting compared to the scorings presented in Grubb et al. (2015), which used a weighting intended to be approximately invariant with respect to the number of criteria (dividing by 2^N). We changed the weighting in response to review comments that this was unnecessarily complex. The scores in this paper therefore differ from those in Grubb et al. (2015) by a factor 2^N / N = 16/6, but this makes no difference to the *relative* scores. We also considered the mathematically more rigorous use of geometric mean, which is the Nth root of the product of N numbers. However, we rejected this because the scores achieved from 6th root of the 6 criteria scores span only a very narrow range, which would give a misleading impression (to policymakers) of very substantial differences in the component scoring (Grubb et al. (2015), Table 5).
8. An example of an **approved technology list** is the UK government Enhanced Capital Allowance (ECA) scheme that allows companies buying technologies listed as highly energy efficient to claim ECAs in their tax returns. This scheme was intended as an economic incentive. However, in practice, its biggest impact has been behavioural, as the listed products became associated with quality and modernity, which incentivised manufacturers to qualify for it (and in the end many purchasing companies never claimed the ECAs).
9. For implementation in the EU, a materials charge would involve either domestic excise duty regimes; or attempts to negotiate an EU-wide excise duty (requiring unanimity); or perhaps most promising (but still complex), significant revision of the EU Emission Trading System to include such a consumption charge.
10. The UKs Carbon Reduction Commitment (CRC) energy efficiency scheme (Grubb, Haney, & Wilde, 2009) offers at least one example of a highly impactful, mandatory business emissions policy instrument; its introduction was hotly contested, but *ex-post* it was estimated to have cut commercial and public sector emissions by 6-8% after its introduction (DECC, 2015), two or three times the initial estimate.
11. Hasanbeigi et al. (2019) reviewed Green Procurement Practices (GPP) around the world, and for the EU reported

    > a 2014 study assessing 160 procurement procedures among relevant EU institutions and bodies showed that more than half of the procurement procedures could not be considered 'green' or were only marginally so. In some cases, the EU's core GPP criteria were very easy to meet or did not go beyond what was already required by other legislation.

    They also, however, report growing use of more impactful GPP contracts since then in some EU Member States.
12. See Grubb et al. (2015) for a brief case study of potential policy packages for the transport sector.
13. www.carboncap.eu/onlinetool.

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Annex: Full scoring results by policy instrument and sector

Note: for Detailed policy instrument description and evaluation by criteria, see Supplemental Material; for detailed rationales for the scores indicated see Grubb et al. (2015).

1. Informational instruments

Mandatory

Transport		Food	Buildings			Paper & plastics	Textiles	Consumer goods & machinery
Vehicles	Fuels		Fabric	Heat	Elec			
Product labels								
18	18	16	32	24	24	16	16	16
Approved technology lists								
54	54	36	54	36	36	54	54	54
Graduated tax on advertising								
0	0	0	0	0	0	0	0	0

Voluntary

Transport		Food	Buildings			Paper & plastics	Textiles	Consumer goods & machinery
Vehicles	Fuels		Fabric	Heat	Elec			
Information campaign								
27	27	27	27	27	27	27	27	27
Product location at sale								
0	0	54	0	0	0	0	54	54
Rankings and Award campaigns								
27	27	27	27	27	27	27	27	27

2. Regulatory and Administrative instruments

Mandatory

Transport		Food	Buildings			Paper & plastics	Textiles	Consumer goods & machinery
Vehicles	Fuels		Fabric	Heat	Elec			
Regulatory standards								
24	24	8	36	#	8	16	16	36
Licenses								
11	11	5	16	5	5	16	11	16
Government procurement								
24	24	24	24	#	24	24	24	24
Recycling requirements								
24	0	12	36	0	0	36	24	36
Product ban								
3	3	3	6	3	3	6	3	6
Waste targets, requirements and/or prices								
24	0	12	36	0	0	36	24	36
Deposits / refunds on purchased goods								
18	0	6	0	0	0	27	27	27
Limits on percentage ownership or use								
2	0	0	2	0	0	0	0	2

Voluntary

Transport		Food	Buildings			Paper & plastics	Textiles	Consumer goods & machinery
Vehicles	Fuels		Fabric	Heat	Elec			
Sector trade body standards								
24	24	8	24	12	12	24	16	36
Business emission agreements / allowances								
24	24	24	36	24	24	36	12	36
Supply chain procurement requirements								
54	54	36	54	36	36	54	54	54
Voluntary agreements by trade organisations								
41	41	18	27	27	27	27	27	41
Extension of product lifetime								
11	0	8	24	0	0	16	0	16
Retailers product choice								
54	54	36	0	36	36	54	54	54

3. Economic and financial instruments

"Externality" pricing
(Consumer cost-raising)

Transport		Food	Buildings			Paper & plastics	Textiles	Consumer goods & machinery
Vehicles	Fuels		Fabric	Heat	Elec			
C-intensive materials charge								
36	0	18	54	0	0	54	36	54
Carbon embodied charge								
12	8	3	18	5	5	8	5	12
Product user fees								
16	16	0	24	8	8	0	0	24
Waste targets, requirements and/or prices								
24	0	12	36	0	0	36	24	36
Minimum price limits								
16	16	8	24	8	8	24	16	24
Business emission agreements / allowances								
24	24	24	36	24	24	36	12	36

Subsidy / incentives
(Consumer cost-reducing)

Transport		Food	Buildings			Paper & plastics	Textiles	Consumer goods & machinery
Vehicles	Fuels		Fabric	Heat	Elec			
Subsidy								
24	36	18	24	24	16	0	12	24
Deposits / refunds on purchased goods								
18	0	6	0	0	0	27	27	27
Product tax incentives								
16	16	16	16	16	16	0	8	16
Trade Env Goods and Services agreements – e.g. tariffs								
36	36	24	36	0	0	36	36	36
Preferential finance terms								
24	24	0	24	12	12	0	0	24

4. Enabling infrastructure and institutional

Mandatory

Transport		**Food**	**Buildings**			**Paper & plastics**	**Textiles**	**Consumer goods & machinery**
Vehicles	Fuels		Fabric	Heat	Elec			
Mandatory metering								
0	0	0	0	18	18	0	0	0
Infrastructure improvements								
54	54	0	54	18	18	0	0	0

Voluntary

Transport		**Food**	**Buildings**			**Paper & plastics**	**Textiles**	**Consumer goods & machinery**
Vehicles	Fuels		Fabric	Heat	Elec			
Enabling recycling								
12	0	6	18	0	0	18	12	18
Enabling product sharing								
24	0	5	27	0	0	0	0	27