Futures 77 (2016) 80–96

Contents lists available at ScienceDirect

Futures

journal homepage: www.elsevier.com/locate/futures

Can low carbon city experiments transform the development regime?

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ARTICLE INFO

Article history:
Received 15 April 2015
Received in revised form 12 February 2016
Accepted 15 February 2016
Available online 18 February 2016

Keywords:
Eco-cities
Transition
Transformation
Urban experiments
Scaling-up
Broadening
Scalar dynamics
Low carbon

ABSTRACT

The paper explores the ability of urban transition experiments to transform the development regime in which they are embedded. Using three European case studies – BedZed, Vauban and Hammarby – it investigates the processes of broadening and scaling-up within cities, nations and across cities globally; and finds that transition experiments do influence the development regime in which they are embedded. The impact of experiments on the development regime does vary significantly with scale. The innovative components, which are assembled in experiments (cultural, structural and practices) also seem to have differing propensity to influence the development regime at different scales. Thus, cultural innovations have a greater propensity to influence the development regime across all scales, whilst the structural and practice innovations tend to influence the development regime locally and nationally. The case studies also demonstrated the significance of context (historical and geographical) in shaping experiments and influencing the transformation process. This finding suggests that the importance of broadening in the transformation process has been overstated. The experiments show that broadening across national boundaries and for prolonged periods, can result in expanding niche-regimes which become increasingly diverse. But it does not result in transformation.

1. Low carbon city experiments

Since the Kyoto Protocol was ratified in Europe in 2002, cities across the region have introduced local carbon dioxide reduction targets and climate action plans. This has led to a proliferation of low carbon experiments in many European cities. These experiments provide a snapshot of how low carbon cities could evolve in the coming decades. They test a range of new technical, regulatory and institutional configurations as well as social practices which are integral to delivering this goal.

This paper explores the contribution transition experiments make towards a low carbon transformation. We draw on transition theories to explore the role of experiments in the transformation process. Transition experiments" are small-scale experiments with a high potential to contribute to transitions, in this case to a low carbon transition (Kemp & Van den Bosch, 2006; Loorbach, 2007; Raven, Van den Bosch, & Weterings, 2008; Rotmans, 2005). Thus, a transition experiment is a specific kind of innovation project.

Experiments are viewed as socio-technical systems – comprised of three elements culture, structure and practices [1] – which address a societal challenge and aim to contribute to a socio-technical transition (Doci, Vasileiadou

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[1] Structure includes: physical, institutional and economic structures.

http://dx.doi.org/10.1016/j.futures.2016.02.003
0016-3287/

Table 1
A framework for analyzing the impact of transition experiments on the regime.

	Processes	Impact	Possible scalar dimension
Broadening	The replication of the experiment in different contexts	Niche-regime	Replication of the experiment in other cities; in the same city at different times; or in different sectors
Up-scaling	The transformation of the regime in which the experiment is embedded	Regime	Change in the regime structure, culture or practices locally, nationally and internationally

Adapted from Van den Bosch and Rotmans.

& Petersen, 2015; Frantzeskaki & Haan, 2009; Loorbach & Rotmans, 2010; Van den Bosch & Rotmans, 2008). Transition theory suggests that experiments can provide the stimulus for the transformation of social-technical regimes,[2] either by replacing or by merging with and transforming the regime (Geels & Raven, 2006; Loorbach & Rotmans, 2010; Smith, 2007).

Experiments can enable social learning; build networks between actors; articulate expectations/visions; and help to align resources (practical knowledge, tacit skills, tools, money and people) needed for new technical systems and associated social practices to diffuse more widely (Geels & Raven, 2006; Loorbach & Rotmans, 2010).

Success is more likely when the incumbent regime is destabilised, usually precipitated by a change in the landscape[3] or when robust niches (comprised of several transition experiments) are compatible with the regime (Geels, 2002). Niches must offer considerable positive feed-back if they are to be adopted by the regime (Smith, 2007). Radical niches will not diffuse widely since they demand too many structural changes (Smith, 2007). In this interpretation, intermediate transition experiments where regime actors take on the innovations developed by the niche, are more likely produce a regime transformation (Smith, 2007). Thus, they are the focus of this research.

Pillar theory provides further insight into the conditions and forces for change (Frantzeskaki & Haan, 2009) which produce transformations. The conditions for change are tension (tensions between the landscape and regime); stress (internal mismatches within the regime); and pressure (pressure on the regime created by the niche-regime). The forces for change include: formation, support forces and triggers. Formation forces demonstrate the potential for societal change (e.g. presence of niche, new demand). Support forces strengthen or weaken transformation processes through the standardisation of practices, provision of resources and exercise of power over the regime. Triggers are crises, systems failures or exogenous events which precipitate transformations. The scalar dynamics of the conditions and forces for transformation need further investigation.

The extent to which transition experiments impact on regime inter-scalar dynamics is still largely unknown. The transition literature provides a useful framework for categorising the impact transition experiments are likely to have on the development regime, through deepening, broadening and scaling-up processes (Van den Bosch & Rotmans, 2008—Table 1). The focus here is on the latter two processes.

The mechanism 'broadening' refers to repeating a transition experiment in different contexts and linking to other domains (Van den Bosch & Rotmans, 2008). The transition literature highlights the importance of: diverse experiments in a variety of contexts (Loorbach, 2007; Rotmans & Loorbach, 2006); translating practices between contexts (Smith, 2007); conducting multiple experiments in niche-trajectories (Geels & Raven, 2006) and a parallel development pattern (Raven, 2005). It is also mentioned in the diffusion literature (Rogers, 2005).

The mechanism 'scaling up' refers to embedding a transition experiment in dominant ways of thinking (culture), doing (practices) and organizing (structure), at the level of a societal system (Van den Bosch & Rotmans, 2008), which could be a city, nation state or international in scale. However, the literature does not indicate the inter-scalar dynamics of these processes.

This paper explores the impact of urban transition experiments on the development regimes inter-scalar dynamics. Here we define the development regime as the dominant culture, structure and practices of those who produce and consume the built environment. It is multi-scalar and cross-sectoral. The actors involved include those governing cities; constructing the built fabric; providing services; and those living and working in cities.

The actors producing and consuming the built environment, and the factors influencing them (policy, regulation, finance, institutions, culture, environment, etc.) may operate at many scales. Thus, an experiment can impact on the development regime locally, nationally or even internationally through these inter-linkages.

Nevertheless, there is sparse consideration as to where socio-technical transitions take place, and the spatial configurations and dynamics of the networks within which transitions evolve (Coenen, Benneworth, & Truffer, 2009). Thus, there is a need for more research into the territorial embeddedness of socio-technical transitions and the importance of local context and scale (Coenen et al., 2012).

Transition experiments develop in a specific context both historically and geographically. Context is fundamentally important in shaping the socio-technical system which emerges (Van den Bosch & Taanman, 2006). Thus, it is questionable the extent to which the lessons learnt from an experiment in one context are transferable to other cities or even other sites

[2] A regime comprises culture, practices and structure of the wider system.
[3] The landscape encompasses a broad range of factors such as economic pressures, cultural values, social trends, wars and environmental issues, which are exogenous to the regime.

within the same city. These concerns have also been highlighted in the policy mobility literature in relation to small-scale experiments (Howlett & Nair, 2015; Vreugdenhil, 2010).

The transitions literature suggests that this reinforces the need to conduct a diversity of experiments within a trajectory in order to learn how best to approach a societal challenge (Van den Bosch & Rotmans, 2008). The importance of repeating transition experiments in different contexts also relates to: innovation literature on diffusion (Rogers, 2005), the notion of speciation or generalization (Levinthal, 1998; Nooteboom, 1999) and geographical or spatial 'scaling up' (Douthwaite, Kubyb, Van de Fliertc, & Schulzd, 2003).

This paper focuses on three urban, low carbon transition experiments: BedZed (London), Hammarby Sjostad (Stockholm) and Vauban (Freiburg). It uses the typology developed in the transition literature of – broadening and up-scaling – to classify the transformation processes observed within cities, within nation states and across cities globally. It uses pillar theory categorisations to identify the conditions and forces leading to transformation. It investigates the importance of context on the transformation process. It examines whether whole models tested in the transition experiments scale-up and explores how the cultural, structural and practice innovations that experiments are composed of, diffuse differentially across a range of scales.

Table 2
Institutions interviewed (46 in total).

	Hammarby	Date of interview	BedZed	Date of interview	Vauban	Date of interview
Government bodies	SKL International (SKL)	2015	London Borough of Sutton—One Planet team	2009/14	City of Freiburg—planning	2009, 2010, 2012
	Business Sweden	2015	Department of Energy and Climate Change	2009	GreenCity Freiburg	2010
	Swedish International development Agency (SIDA)	2015	Department of Local Government and Communities	2009	KfW Bank (KfW)	2009
	Malmo City Council (MCC)—Sustainable Development Unit	2009/14			Federal Ministry Environment, Nature Conservation, Building and Nuclear Safety (BMUB)	2009/10
	Stockholm City Council (SCC)—Strategic Planning	2009/15				
	Stockholm City Council—Planning Officer—Hammarby Projec	2009				
	City Council- Planning Officer—SRSP Project	2009				
	County—Planning	2015				
Consultants	SWECO	2015	Bioregional	2009	Disch Architects	2009
	Tengbom	2015	Zed Factory	2009/14		
	WSP	2013/15	ARUP	2009		
	Urban Earth Consulting	2015				
Industry	SKANSKA construction (Sweden)	2009	Zero Carbon Hub	2010	Badenova	2009
	NCC construction (Sweden)	2009	Crest Nicholson	2010		
	Fortum	2009	Barratt Homes	2009		
	E-ON (Sweden)	2009	Quintain	2012		
			E-ON	2012		
			EDF	2012		
			Utilicom	2009		
			House Builders Federation	2010		
Community					Forum Vauban	2009
					Triangel	2009
					GENOVA	2009
					FESA eV	2009
Academic/ research institutions	Swedish Environmental Research Institute	2009/15	Building Research Establishment	2009	University of Freiburg	2012/13
	KTH Stockholm	2009/15			Fraunhofer Institute for Solar Energy	2010
					Öko-Institut	2010

2. Zero carbon realities project

The Zero Carbon Realities project used a comparative methodology, to examine the questions outlined above, in a number of European cities. The case studies were exploratory, attempting to understand the extent to which the transition experiments had influenced the development regime. The study used several data sources:

- Detailed interviews with development regime actors (Table 2)
- Analyses of plans (strategic, local, low carbon, infrastructural); technical reports; policy and legal documents; academic articles; company reports; websites; government and governmental networks websites and newspaper articles.

The data was analysed using a combination of historical event analysis and mapping techniques to determine the impact of the experiments on the development regime at different scales. The historical analysis helped to identify the chronology of events which had precipitated the experiment and influenced the broadening and scaling-up processes. Mapping was used to trace the movement of innovative cultural concepts, structures and practices developed by the transition experiments across range of scales. The results are presented in the following pages.

3. Urban transition experiments

The urban experiments were chosen based on several key criteria (Table 3). They were all:

1. Exemplary—thus CO_2 emissions from the experiment were significantly lower than for the city in which they were embedded;
2. Established—to enable an historical analysis of impact on the regime;
3. Cross-sectoral—involving several urban sub-systems;
4. Intermediate—as according to the literature they were most likely to bring about a transition;
5. Innovative—demonstrated innovation in cultural concepts, structures and practices.

3.1 Hammarby—Stockholm

Hammarby Sjostad is a mixed-use, high density district, built on a brown-field site in the centre of Stockholm. When complete it will house 20,000 residents. It tackles CO_2 emissions by increasing system efficiency (low energy buildings, public transport, and district heating) and substituting fossil fuels for renewable energy or waste (eco-cycles system). It is

Table 3
The case studies.

	Hammarby	BedZed	Vauban
City in which low carbon experiment developed	Stockholm	London	Freiburg
First phase completion	2004	2002	2007
Systems involved	Buildings, waste, water, energy, transport	Buildings, waste, water, energy, transport	Buildings, waste, water, energy, transport
Carbon production in city (tonnes per capita/annum)[a]	4[b]	12.5[c]	8.5[d]
Carbon production in experimental neighbourhood (tonnes/capita/annum)	2.5–3.0[e]	0.51[f]	0.5[g]
Cultural innovation	SYMBIOCITY concept[h]	Zero carbon; Zed and One-Planet concepts	Solar city concept
Structural innovation	Eco-cycles system; energy efficient building;	Low carbon technologies and urban design (the Zed system)	Low carbon technologies; Local code for improved energy performance in buildings; institutions for co-provision
Innovation in practice	Integrated systems planning	One-planet sustainable lifestyle concept; One-planet framework for managing development	Co-provision (energy, housing and built environment); collaborative planning

[a] Cross comparison of cities and experiments CO_2 savings should not be made since the calculations may have been made using different assumptions. However, it does provide an indication of the scale of CO_2 savings made by the experiment within a given city.
[b] City of Stockholm (2009).
[c] Minx et al. (2013).
[d] ICLEI Local Governments for Sustainability (2009).
[e] Brick (2008).
[f] Bioregional (2009).
[g] ACT Planning and Land Authority Planning Services Branch (2010).
[h] Circular metabolism, systems-based thinking, integrated urban systems, resource decoupling, resource efficiency, low carbon and sustainable development.

estimated that an average Hammarby resident produces 2.5–3.0 tonnes of CO_2/capita/annum (compared to 4 tonnes for the average Stockholm resident).

The Hammarby experiment was driven by Stockholm City Council and implemented by construction companies and city-owned utilities (all key players in the development regime). Thus it was an intermediary experiment. The underlying concepts – circular metabolism, low carbon buildings, integrated planning – were all supported by the Swedish government, but the structures and practices needed for delivery had not been developed. Thus, Hammarby along with other Swedish urban transition experiments (most notably B001 Western harbour Malmo) materialised and operationalised these concepts.

Structurally, Hammarby developed an innovative technical solution – eco-cycles system—with the aim of creating circular resource flows and improving resource efficiency (Fig. 1). The system utilised the existing, proven city-wide infrastructural systems (city-wide district heating system; the Högdalen combined heat and power plant and the Hammarby thermal power station) with new technologies for converting sludge into fertiliser and biogas and producing renewable energy on-site (Pandis, Johansson, & Brandt, 2013). Of these innovations the biogas element has been successful, used by buses in Stockholm and biogas cookers in Hammarby.

The buildings in Hammarby have also been designed to be more energy efficient (consuming 60 kWh/m^2/year), with solar cells, solar collectors and fuel cells in some units (Pandis et al., 2013), although when the energy declarations of the buildings were analysed in 2013 (Bennewitz & de Frumerie, 2013:18, 16–18 pp.) and the average level of energy use was more than twice as much as the original target.

In terms of practice, Hammarby pioneered an integrated planning process, to enable the successful delivery of the eco-cycle system (Williams, 2011, 2013). It engaged multiple stakeholders from the regime (i.e. the municipality, construction industry and other service providers) to participate in the visioning, design and development process. It was iterative,

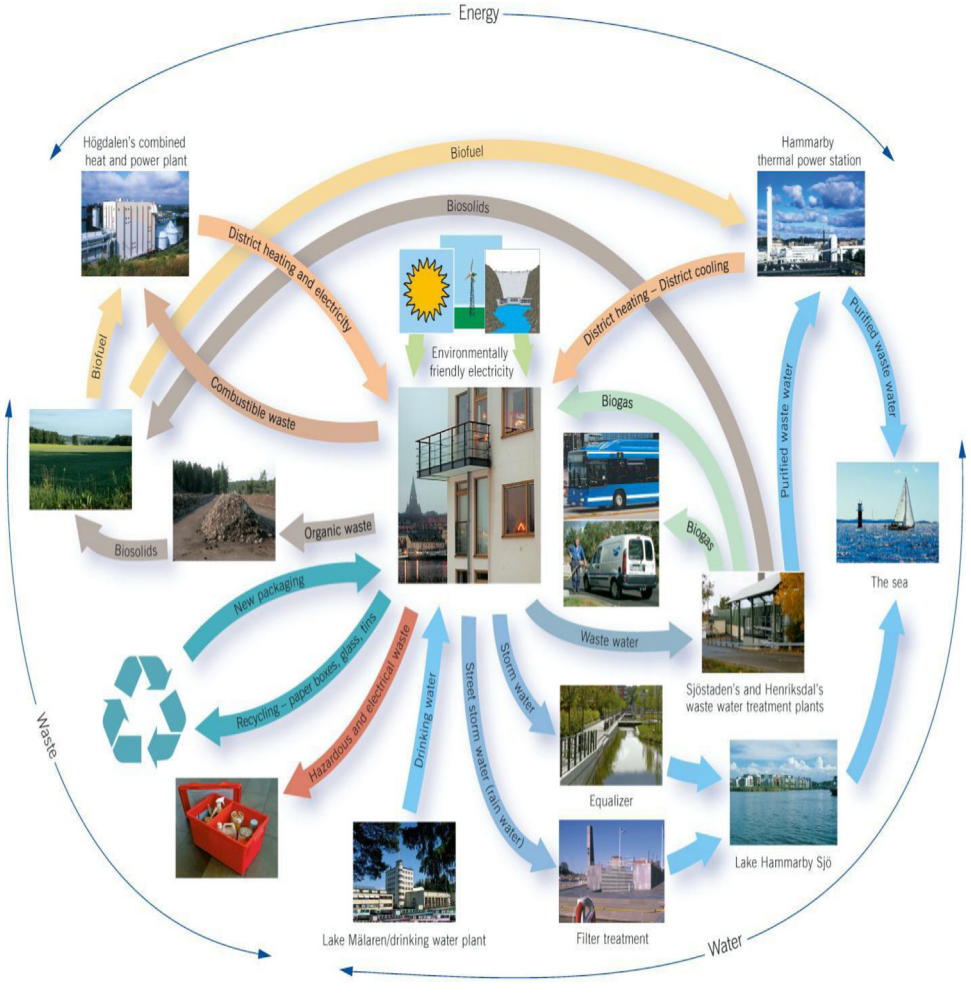

Fig. 1. The eco-cycle system (Hammarby website, 2010).

dynamic and inclusive process, bringing key stakeholders together to create integrated and holistic urban systems. The process stimulated both co-production and learning processes amongst key stakeholders in the development regime.

Hammarby was one of several transition experiments conducted in Swedish cities. Subsequently a second wave of urban experiments have emerged (a decade later) that updated and diversified the model (broadening). The integrated planning process has become embedded in the development regime locally and nationally (scale-up). It has also been exported to Asia and Africa (broadening). However, there is no evidence that Hammarby's technological innovations have scaled-up locally, nationally or internationally. New management models and technologies have emerged during the second wave of Swedish transition experiments (reflecting the new context), which have also led to a broadening process at a local and national level.

3.2 BedZed—London

BedZed is probably the best known (and oldest) zero carbon experiment in London, completed in 2002. It is a mixed-use, medium density development, built on a brown-field site in a suburban London borough. It houses 244 residents. BedZed tackles CO_2 emissions produced by a variety of household activities (including travel, consumption of food and production of waste), those produced by thermal demand and electricity consumption in the home. It is estimated that an average BedZed resident produces 0.51 tonnes of CO_2/capita/annum (compared to 12.5 tonnes for the average London resident).

BedZed is an intermediate experiment driven by actors embedded in the development regime—ZedFactory, Bioregional, Arup, Gardiner and Theobald and Peabody Trust – and supported by the London Borough of Sutton, through the allocation of municipally owned land. At the time it was built, the project was highly innovative, differing considerably from the wider development regime in which it was embedded.

BedZed adopted the zero carbon concept (cultural innovation) which it materialised through the application of the Zed design and One-Planet Living concepts. The Zed design concept was a structural innovation. It utilised technological (energy-plus/low energy dwellings, electric vehicle charging points, district heating system) and design solutions (mixed-use, medium densities, live-work units, layout to maximise solar gain) to tackle CO_2 emissions. The One-Planet Living concept was a practice innovation which encouraged residents to alter their lifestyle, to share resources (e.g. the car pool), use locally sourced materials (e.g. woodchip to power CHP system) and work locally (e.g. live-work units).

BedZed seems to have influenced the development regime across several scales. At a local scale the one-planet concept has influenced the London Borough of Sutton's approach towards development and management of urban processes through the "one-planet Sutton programme" (up-scaling). At a national scale it provided a benchmark for the zero carbon standard which led to the national transformation of the development regime, albeit temporary (up-scaling). ZedFactory and Bioregional have also exported the zero carbon concept (thinking), Zed system (design and technical systems) and One-planet concept (practice) to other locations in the UK and globally (broadening).

3.3 Vauban—Freiburg

Vauban is probably the best known low carbon (solar district) experiment in Freiburg (although there are many others e.g. energetic retrofits, community-owned renewable energy schemes, etc) dispersed across the city. It is a mixed-use, medium density development, built on a brown-field site in the medium-sized city in Southern Germany. It houses 5000 residents. The average Vauban resident produces 0.5 tonnes of CO_2 annually, compared to the city average of 8.5 tonnes/capita/annum.

Vauban is an intermediate experiment involving actors from the development regime (Freiburg city council, a local energy company, construction companies, self-builders, cohousing groups, housing cooperatives and other community groups). The municipality provided the site for the Vauban experiment and drove the planning process, but the majority of the decisions concerning design, implementation and management have been made by citizens living in the district. Vauban is a product of local policy which promotes the solar city (integrated into the city's spatial planning and economic development frameworks) and pursues energy efficient development (through local building code). It is also supported by Federal funding (feed-in tariff and KfW loans).

Vauban materialises the solar city concept. It combines structural innovations: technologies (energy-plus and passive houses), institutions (community fora,[4] baugruppen[5] and community energy cooperatives[6]) and regulation (local code for improved energy performance in buildings) to deliver a solar (low carbon) district. Innovative social practices (co-provision and collaborative planning process) have also emerged in the district (Williams, 2013).

The experiment has partially transformed the local development regime in which it is embedded (scaling up). The collaborative planning process and energy efficiency standards adopted in Vauban have been applied across the city and are now influencing new development. However, there is no evidence of Vauban either transforming the regime or becoming a niche-regime, nationally or internationally.

[4] Community fora emerged from the Vauban and Rieselfield urban experiments.

[5] There are currently 1100 Baugruppen in Freiburg (Hamiduddin & Daseking, 2014).

[6] Community energy cooperatives first emerged in other parts of the city, but also appeared in Vauban. There are 120 community energy cooperatives (CEC's) in Baden-Wutternberg. The largest is FESA, which has raised €20 M for regional energy projects and has 700 shareholders. So far it has constructed 9 citizen windmills, 8 solar power plants, 1 hydroelectric plant, 1 power saving plant and completed energetic retrofits for many buildings.

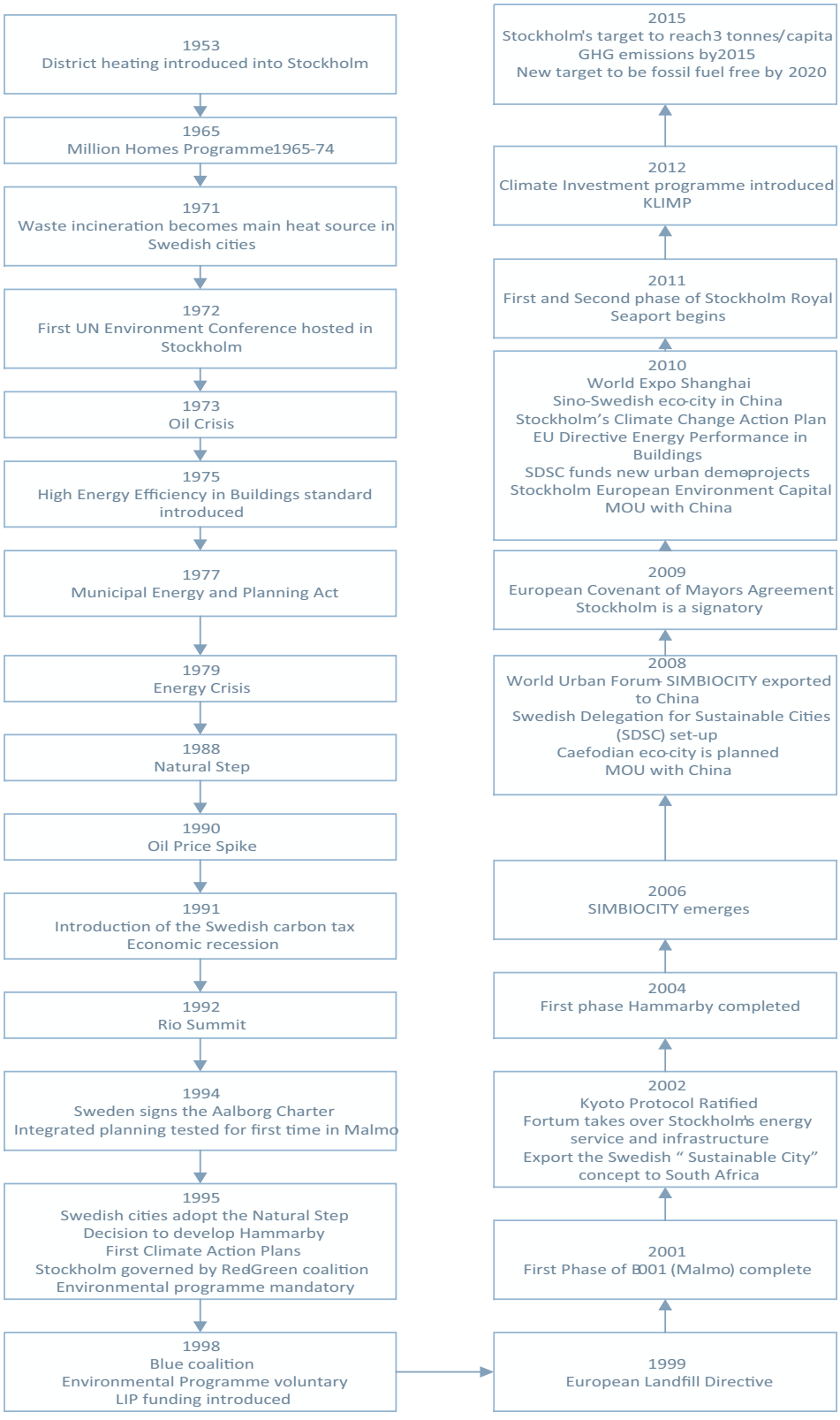

Fig. 2. Hammarby time-line.

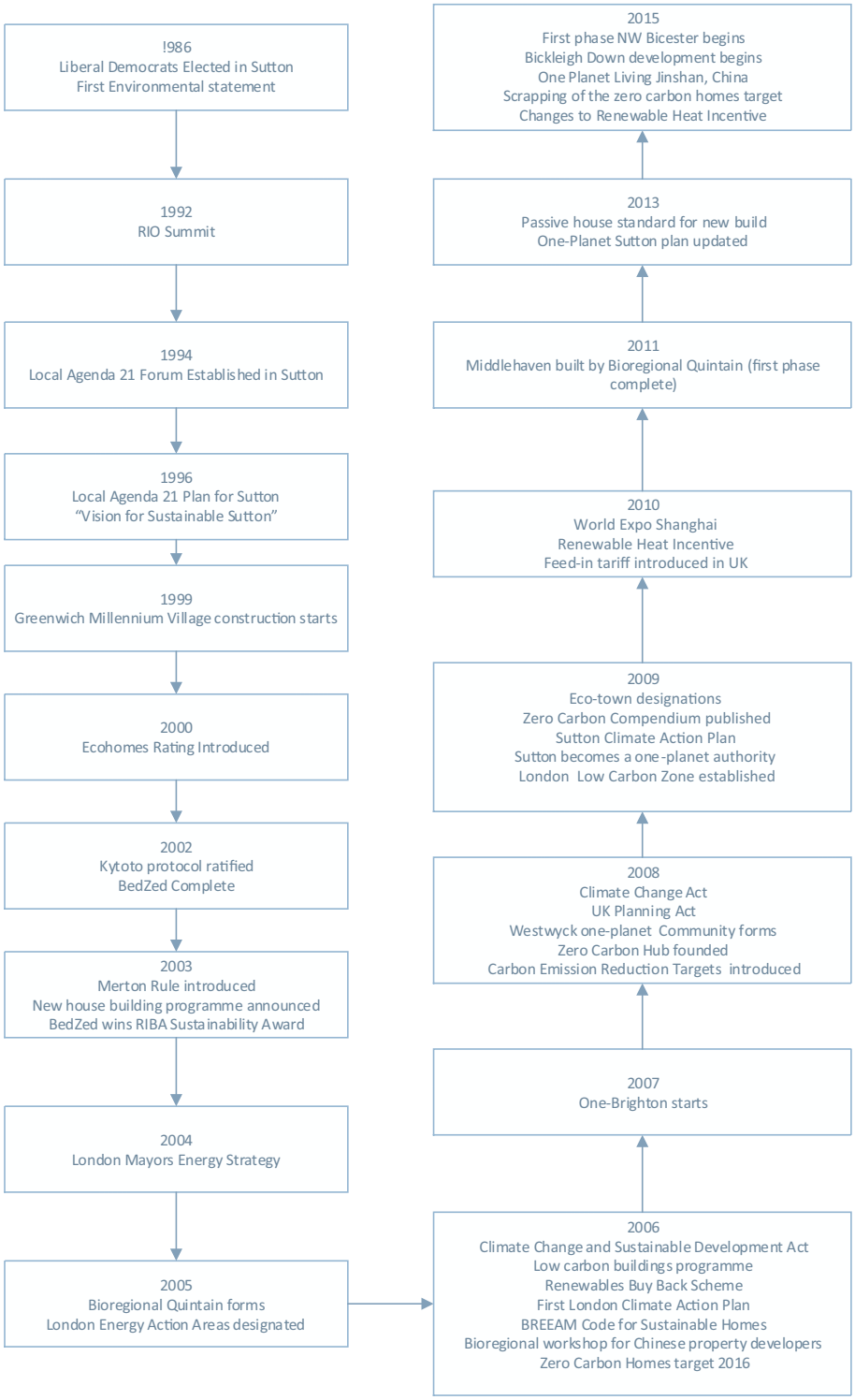

Fig. 3. BedZed time-line.

4. Historical time-lines

Constructing historical time-lines for each experiment enables us to determine what changes in the landscape and development regime, have resulted in the emergence, broadening or scaling-up of experiments. It helps to identify where in the transformation process experiments have emerged, and whether they are part of a wider movement. Thus it helps to analyse the extent to which experiments have proved transformative and the importance of historical context in the transformation process.

4.1 The Hammarby experiment

Hammarby was one of several low carbon urban experiments, developed in two waves across Swedish cities over a 10 year period (e.g. Stockholm, Malmo, Växjö, Gothenburg, Uppsala, Linköping, Umeå). Collectively, these could be described as a niche-regime. In the first wave, Hammarby and B001 (Malmo) were the earliest transition experiments. The first phases were completed 2004 and 2001 respectively (Fig. 2).

These projects incorporated several innovative concepts which had become popular within Swedish government (national and local) over a 30 year period – systems thinking, holistic solutions, circular metabolism, integrated infrastructure planning and low carbon development – but had not yet materialised. Governmental interest in the "natural step" and subsequent adoption of the Alborg Charter (Conference Sustainable Cities and Towns, 1994) embedded these concepts into Swedish cities by 1995. Thus these innovative concepts were culturally embedded in governmental institutions.

Their materialisation was encouraged through the allocation of funding streams for new urban quarters – Local Investment Programme 1998, Swedish delegation for Sustainable Cities 2008 and Climate Investment Programme 2012 – which enabled the key stakeholders in the development regime to determine the structures (e.g. regulation, funding) and practices (e.g. construction techniques, integrated planning) needed to support the implementation of these innovative concepts.

Structurally, the technical capacity to deliver the eco-cycle system also developed in Swedish cities (including Stockholm) over several decades. District heating systems powered by waste, decarbonised energy mix and energy efficient buildings have been part of mainstream development models in Swedish cities for some time. The district heating system was introduced in Stockholm in 1953 to tackle pollution and increase energy efficiency.

The shift in energy mix in Stockholm towards waste (69% of waste is used for district heating) and renewables (80% power and heating is from renewable sources in Stockholm County) was driven by the oil and energy crises of the 1970's, Municipal Energy Act 1977 (SFS, 1977) and latterly by the European landfill tax (European Union, 1999).

The national million homes programme (1965–1974) created capacity within the Swedish construction industry to deliver very energy efficient housing. The programme led to the introduction of higher energy efficiency standards for buildings in 1975. Thus energy crises, regulatory and technical changes since the 1950's have produced the urban infrastructure underpinning the eco-cycle system in Sweden today.

The Swedish government (Swedish International Development Agency, Business Sweden, SKL[7] International, Swedish National delegation of Sustainable Cities) and Swedish urban consultants (SWECO, Tengbom[8]) began to export aspects of the Hammarby model globally (particularly to Asia and Africa) initially as the sustainable city brand (2002) and later packaged as SYMBIOCITY (2007). SYMBIOCITY incorporated the integrated, planning approach but it also acted as a platform for Swedish technologies (SKL International, 2012).

SYMBIOCITY was first introduced to China via the World Urban Forum (2008) and again at the World Expo (2010). The ideas of decoupling, circular metabolism and circular economy were of great interest to the Chinese (Hult, 2014). The Swedish government exported SYMBIOCITY to China, using several memorandums of understandings signed between 2008 and 2010 (Froberg, Herodes, Jessup, & Zingmark, 2013). However, although there is evidence of collaboration with cities in Asia, in some instances resulting in master-plans, there is limited material evidence of broadening or transformation of the development regime in a global Asian urban context.

A second wave of experiments began in Swedish cities from 2011. These continued to focus on the core cultural concepts underpinning the first wave experiments, but switched from largely technical solutions, towards models for community engagement, managing multi-stakeholder systems and funding energetic retrofit. Stockholm Royal Seaport (SRSP) is a second wave experiment being built in Stockholm. These experiments provide examples of the broadening of the niche-regime locally and nationally.

4.2 BedZed experiment

Innovative, low-carbon, housing solutions had not gained a foothold in the local or national development regime when BedZed was constructed in 2002 (Fig. 3). Unlike Hammarby, there was no national, regional or local framework (policy, regulation or funding) which supported the experiment. The Ecohomes rating (Building Research Establishment, 2000), a voluntary code, was the only benchmark in existence and Greenwich Millennium Village (1999) the only other eco-project in London at the time. In 2003, BedZed won the RIBA Sustainability Award which enhanced its public profile. Interest in low

[7] SKL is the Swedish Association of Local Authorities and Regions. SKL International is the international company owned by the SALAR who act as consultants to cities globally.

[8] SWECO Swedish engineering consultants; Tengbom Swedish Architectural consultants.

carbon solutions was growing in London reflected by the emergence of the Merton Rule (2003), the Mayors Energy Strategy (Greater London Authority, 2004) and Energy Action Areas (2005) of which Sutton was one.

By 2005, Bioregional set up a joint venture with the volume house builder Quintain, forming Bioregional Quintain. The aim was to demonstrate that existing actors in the construction regime could build zero carbon housing. These new developments (also largely experimental) combined the technical and lifestyle aspects of the BedZed concept (broadening). One-Brighton (Crest Nicholson and Bioregional Quintain Partnership) and Middlehaven (Bioregional Quintain) demonstrated that the zero carbon concept could be replicated in other British cities, and built by volume house-builders (interview with Quintain). However, the partnership between Bioregional and Quintain Homes dissolved by the end of 2011 (despite their success in gaining contracts for new developments) leaving the Middlehaven project part complete. It seemed the local political processes, central government policy changes and economic uncertainties in 2011 led to its demise (Waite, 2011; interview with Quintain).

Nonetheless, the Government used BedZed as an example of best practice for low carbon development, along with other models from Europe. BedZed reportedly provided the inspiration for both the *BREEAM Code for Sustainable Homes*, 2006 (a voluntary code) and the mandatory 2016 zero carbon target for all new houses (Bioregional, 2009). Certainly the Buildings Research Establishment (BRE) used BedZed as the benchmark for environmental best practice in residential schemes (equivalent to code level 6). The code drew on both the one-planet concept and zed system which later fed into Government thinking (BRE interview and DCLG, 2006a,b).

In 2003, the Government announced a major new house building programme to provide 2 million homes by 2016 (Office of the Deputy Prime Minister, 2003). After the Climate Change Act (Great Britain, 2008) the domestic sector, and particularly new build development, was seen as the low-hanging fruit which could be targeted in order to achieve its 2050 CO_2 reduction targets (Interview with DECC). The 2016 target for housing was set in 2006, alongside a pathway for progressive increase in energy efficiency requirement through building regulations. The intermediary target for achieving passive house standard was set for 2013. This pathway was reinforced by the updated European Energy Performance in Buildings Directive (European Union, 2002) in 2010, which stipulated that all new buildings and major refurbishments in Europe would need to meet zero-net energy standard by 2018.[9]

The zero carbon target was supported by a number of additional policy instruments (Williams, 2010) including: carbon emission reduction targets for the energy industry (2008), the feed-in tariff (2010), renewable heat incentive (2010) and a capital grant for low carbon buildings (Low Carbon Buildings Programme, 2006). Thus the national and international regulatory and funding landscape appeared to support progression towards zero carbon.

The Zero Carbon Hub formed in 2008 to help build capacity within the construction and energy industries to deliver the target for new homes by 2016. After a slow start, the construction and energy industries began to build their capacity to deliver zero carbon homes in partnership (interviews with Zero Carbon Hub, Barratt, EDF, E-ON, Utilicom and Crest Nicholson).

The regulatory and funding framework stimulated the beginning of this cross-sectoral transformation process, up-scaling nationally the zero carbon concept first pioneered in BedZed. It encouraged the development of new supply chains, skills and expertise, models of construction and the formation of partnerships between the construction and energy sectors (e.g. Barratt Homes partnership with E-ON, EDF and Utilicom) to build zero carbon homes (interviews with Zero Carbon Hub, Barratt, EDF, E-ON, Utilicom and Crest Nicholson).

A change in national political control in 2010 led to change in priorities, loss of supportive policy (dismantling of planning system), reduction in funding (particularly for community renewable energy) and watering down of the zero carbon homes target. By 2015 the new conservative government had scrapped the zero carbon target. Thus, the national transformation of the development regime stalled.

Since the completion of BedZed, ZedFactory and Bioregional have been separately involved in a variety of community projects adopting the Zed system and one-planet concept in the UK (One-Planet Brighton, 2007; Middlehaven 2011, NW Bicester and Bickleigh Down, 2015) and internationally (e.g. Westwyck Ecovillage, 2008; Jinshan, 2015; Caofeidian Ecocity, 2011, Shenzen, 2015). Both concepts have diversified over the period 2002–2015 (interviews with ZedFactory and Bioregional).

Bioregional now offers a one-planet approach to local authorities (London Borough Sutton, 2009; Middlesbrough, 2011; Brighton, 2013; Freemantle, 2015) and businesses (B&Q, 2007; John Lewis, 2012). Zed factory during the same time period has produced an array of new technical solutions including solar bikes, zero bills homes, zed rooves, etc. Both have participated in events to market their concepts to China (e.g. via World EXPO in 2010, various workshops for Chinese developers and government officials from 2006–15). Thus, there has been a broadening process at national and international scales.

At a local level the one-planet principles were adopted by the London borough of Sutton in 2009 (scaling-up). The borough has supported the green agenda for 30 years. The Liberal Democrats have controlled the council since 1986, when they introduced a ground-breaking environmental statement. In 1994, a local agenda 21 forum was established which produced a "Vision for sustainable Sutton" (Sutton Council, 1996). This guided development within the borough until 2009, when the Climate Action Plan (Sutton Council, 2009a). and One-Planet Sutton (Sutton Council, 2009b). were introduced.

[9] This standard has been since reduced, to "nearly zero energy by 2020".

The principles of one-planet living have become embedded in all Sutton's decision-making processes – planning, procurement, management, policy-making – which has transformed the local development regime (interviews with Sutton

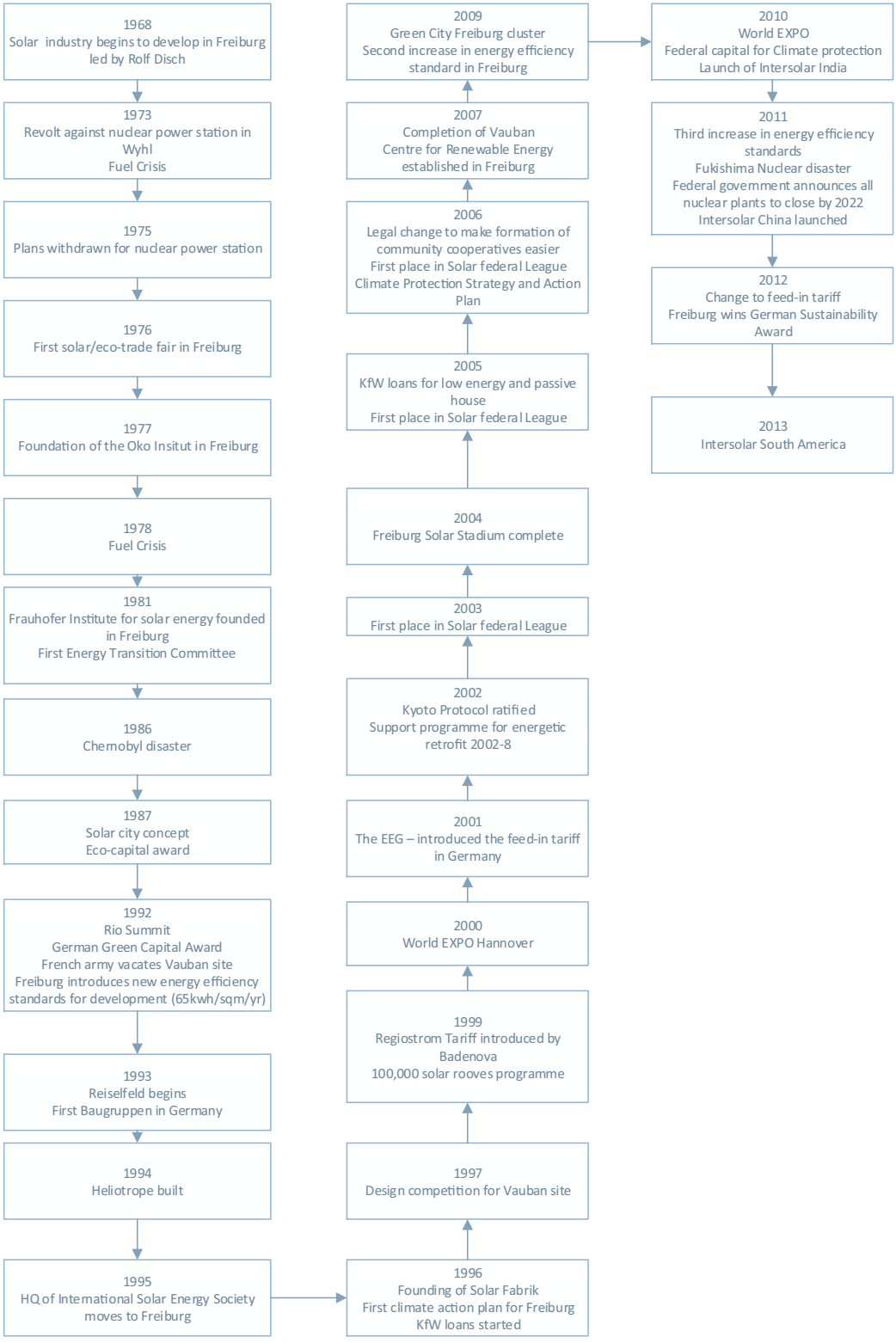

Fig. 4. Vauban time-line.

Council; Sutton Council, 2009b, 2014). Monitoring suggests that this is having a positive impact on CO_2 emissions from council vehicle fleets and all building stock (council owned buildings and residential stock); residents recycling behaviour and the adoption of the environmental educational programmes across the borough (Sutton Council, 2014).

Since 2011, more than £8.5 m of funding has been brought into the borough to help deliver projects contributing to its One Planet Sutton targets, and the council has made over £1.9 m savings from improving its use of energy (Sutton Council, 2015). However, it did not result in the construction of more zero carbon homes. One Planet Sutton was reviewed in 2013 and continues to inform development decisions across the borough in 2015.

4.3 Vauban experiment

Vauban's emergence is underpinned by a number of historical events, which contributed to a shift in culture, structures and practices in the city over 40 year period (Fig. 4). The solar industry in Freiburg began to develop in 1968, led by architect Rolf Disch. In 1973, a protest movement against the construction of a nuclear power station in Wyhl emerged comprising a coalition of wine growers, students and local citizens. The protest was successful and plans for the power station were withdrawn in 1975. The Öko-Institut (an environmental research institute) also emerged from the anti-nuclear movement in 1977. The Fuel crises of 1973 and 1978 raised local concerns about energy security. In 1986, the Chernobyl disaster produced public opposition to nuclear power across the whole of Germany. These events combined to produce a cultural shift within Freiburg towards support for renewable energy.

Freiburg is one of the sunniest places in Germany, with 1,800 hours/year of sunshine and an annual radiation intensity of 1117 kW/m2. Renewable energy expertise developed locally from the 1960's onwards, particularly in solar technology. In 1976 Freiburg hosted its first solar/eco-trade fair, run by a local activists from the anti-nuclear movement (many were local academics). The Öko-Institut established an energy transitions committee (ETC) in the city during the 1980's, which coincided with the founding of the Fraunhofer Institute for Solar Energy (ISE) in 1981(now the biggest solar research institute Europe).

By 1984, Wulf Daseking was appointed as Director of City Planning. He worked closely with Rolf Böhme (Mayor of Freiburg), local visionaries (Rolf Disch), research institutes (e.g. Öko and ISE) and with the ETC to devise a road map for a local energy transition. This coalition recognised the potential for innovation and economic growth, and championed a plan to grow the city's solar sector, alongside improving energy efficiency—the Solar City Concept (1987). The coalition was critical to the transformation process.

In 1992, the city introduced energy efficiency standards for buildings on municipally-owned sites of 65kwh/m2/year. This was the base standard applied in Reiselfeld and Vauban (two mixed-use, infill developments). In 1993, the Reiselfeld development began. It pioneered not only the low energy standard, but also a more collaborative form of planning, which involved residents in decision-making. It also produced the first baugruppen (self-build groups). However, no renewable technologies were included in the development.

In 1994, Disch built the Heliotrope, which demonstrated the potential for solar housing. Over the next two years the International Solar Energy Society moved its headquarters to Freiburg and many solar companies emerged. From 1996–2000 the introduction of various subsidies (e.g. the local Regiostrom tariff,[10] and federal KFW loans and 100,000 solar rooves programme) supported the diffusion of energy efficient buildings and solar technologies across the city. The Federal Renewables Law was adopted by the government in 2001, which introduced the feed-in tariff. This law was fundamental to the diffusion of renewable technologies across Germany and in Freiburg.

The French army vacated the Vauban site in 1992 and the development was complete in 2007. Vauban took structural and practice innovations from Reiselfeld and developed them by: increasing energy standards in selected locations (to passive house and energy-plus standards); diversifying the mechanisms for co-provision (community fora, cohousing, self-build, cooperatives) and including solar technologies. It also developed the collaborative planning process adopted in Reiselfeld.

Vauban materialised the solar city concept in Freiburg. It provided actors in the local development regime with a clearer indication of what was needed to move towards a solar city in the future. By 2009 the new energy efficiency codes were adopted citywide for municipal sites and the collaborative planning approach was used to develop the 2020 spatial Plan.

The Fukushima nuclear disaster and subsequent Federal Government announcement in 2011 that all nuclear plants would close in Germany by 2022 seemed to provide further support for the adoption of solar solutions in the city. However, changes to federal feed-in tariffs announced in 2012 limited the ability of community cooperatives to fund renewable energy projects, critical to the diffusion of solar technologies in Freiburg. In addition, some of the local champions for solar city Freiburg have retired. Both changes may pose a threat to its continued success.

However, since the completion of Vauban, the Green City Freiburg Cluster has been established (2009) linking up the 145 cross-sector cluster stakeholders from the solar and environmental industries. It is being used as a vehicle for building capacity to deliver renewable energy expertise within Freiburg, and to market expertise to a global audience.

The World Expo in Shanghai 2010 took Vauban and Freiburg to Asia. China and India showed a great deal of interest in the application of solar technologies. The Intersolar trade (fair previously hosted in Freiburg) went on a global tour to India (2010), China (2011) and South America (2013). However, as yet there is no evidence that the Vauban model has travelled to new contexts, although in 2010 India did announce a solar city programme.

[10] To date 89 community renewable energy projects and 2000 citizen energy units have been funded by the Badenova Regiostrom Tariff, creating carbon savings of approximately 400,000 tonnes CO_2/annum (Badenova website, 2009).

5. Scalar dynamics of the transformation process

The transition experiments demonstrate the scalar dynamics of the transformation process. All three had some impact on the development regime at different scales.

5.1 The Hammarby effect

Stress in the national development regime produced the first wave of experiments in Swedish cities (including Hammarby). These in turn created the internal pressure within the local and national regime for change. This led to the adoption of the integrated planning approach locally and nationally by the Swedish development regime (transformation). Broadening processes, emanating from the first wave of experiments, have also impacted on the development regime at all scales.

By 1994, it was apparent that there was an internal mismatch within the national development regime between what government wanted developed (in line with the SYMBIOCITY concept) and what was being built in cities (Stress). The Government introduced funding[11] to support the transformation, process using urban experiments (support force), which created the beginnings of a national niche-regime. Thus, the SYMBIOCITY concept became embedded in the thinking of those governing, designing and building cities in Sweden.

The niche regime generated pressure for adopting the integrated planning approach tested in Hammarby and B001 (formation force). This led to the standardisation of practice across cities and consultancies delivering urban projects (interviews with Stockholm City council [SCC], Malmo City Council [MCC], SKL, SWECO, WSP, KTH Royal Institute of Technology [KTH]). It is now the approach adopted by Swedish cities when planning new urban districts (support force).

The eco-cycles system and low energy building code (tested in Hammarby and B001) have not scaled-up. Interviews with Fortum, Skanska, NCC, E-ON, SCC and MCC suggest that a national regulatory framework is needed for companies to invest in the innovative technologies and practices developed in both experiments. However, the national energy efficiency standard for buildings has not increased as a result of these transition experiments (Swedish Environmental Research Institute interview). Thus, construction and energy companies weren't prepared to alter their existing development models.

Major changes in landscape have also occurred since the first wave experiments in Sweden, which have impeded the scaling-up of the structural changes tested in the first wave experiments. Political and international regulatory changes have affected the institutions operating at a local level (Williams, 2011, 2013; Vestbro, 2002). The privatisation of energy services and infrastructure in Swedish cities has reduced local governments' ability to integrate systems and determine energy mix. In addition, more publicly-owned land is being sold to private investors in Swedish cities to raise revenue. This has also reduced city council's ability to impose environmental programmes on future development (interviews with SCC and MCC).

Thus, second wave experiments are being used to test new management, financing and operational models for low carbon infrastructure. They are also testing smart technologies (e.g. Hyllie and SRSP); vehicles for engaging citizens in decision-making processes and encouraging behaviour change (e.g. Hyllie, SRSP and Rosengård). Hammarby and B001 experiments highlighted the importance of monitoring the environmental performance of projects and enforcement (interviews with SCC planners, Head of MCC sustainability unit). They demonstrated the importance of community involvement in the development process and finding ways to address consumer behaviour.

The second wave experiments are continuing the broadening process, developing a range of optimal solutions for the emerging urban context. However, there is a danger within a continually changing landscape, this process could produce a growing number of transition experiments, without creating stability in the niche-regime or resulting in a national transition.

The international broadening of the SYMBIOCITY concept, has been driven by the identification of potential international demand – formation force – (interviews with SKL, SWECO, KTH, Business Sweden, 2014). Some suggest that the Swedish urban experiments are increasingly focussed on export (Hult, 2014) rather than local or national transformation.

SYMBIOCITY is diffusing to new global contexts. The eco-cycles system is particularly popular in China, incorporated into several projects: Caofeidian, Wuxi, Dongli Lake Project, Luodian Town. To date these projects have progressed only to the master-planning stage, with the exception of Caofeidian Eco-city. However, this project is currently failing as a result of change in local leadership and severe lack of funds (Yu, 2014; Liu, Zhou, Wennersten, & Frostell, 2014).

There have been some difficulties transferring the eco-cycles system to the Chinese context. For example, building codes prevented the use of district heating/cooling systems in the southern provinces in China (interview with Tengbom). Also the Chinese preferred small system solutions for buildings (similar to the BedZed) rather than city-wide or community level solutions, as developed for Hammarby (interview with Urban Earth Consulting). The reasons given were cultural (distrust in large-scale, government owned systems) and economic (private investors preferred building level solutions).

There is evidence that an attempt is being made to export the integrated planning approach to other parts of Asia (Indonesia, Singapore, India) and Africa (Zambia, South Africa) by SWECO and SKL International. This process-based approach is by its nature context relevant, and thus transferable. Yet in practice siloed-thinking embedded in institutional structures; lack of expertise and opposition to wider stakeholder engagement in decision-making processes has made it difficult to implement in master-planning exercises let alone in implementing projects (interviews with SKL International, Urban Earth Consulting).

[11] Local Investment Programme 1998, Swedish delegation for Sustainable Cities 2008 and Climate Investment Programme 2012.

5.2 The BedZed effect

BedZed has impacted on the development regime at all scales. It seems to have played an instrumental role in the transformation of both the national and local development regimes. The national transformation process was precipitated by stress within the national development regime, triggered by the Government's dual (and mismatched) needs to tackle CO_2 emissions and deliver a new housing programme. The BedZed model provided one solution for achieving both aims. New housing that produced no additional (or limited) CO_2 emissions and generated clean energy. BedZed informed the 2016 zero carbon target introduced by the Government. The target, national energy escalator and European Directive provided the driving force for change in the national development regime (support force). The zero carbon hub then helped to build capacity in the construction and energy industries to deliver the target (support force).

At a local level the situation was quite different. The conditions were supportive of alternative, environmentally-friendly approaches to development. In Sutton, BedZed demonstrated the potential for societal innovation (formation force). The one-planet framework was adopted by the Borough, then operationalised through its policy-making, management, procurement and planning processes. Thus, the one-planet principles were standardised into the practices of the local authority and guided resource allocation (support force).

The BedZed concepts were also applied to new sectors and geographical contexts (broadening). Bioregional tested the one-planet living concept in new sectors including local government and business. The concept was also used as a basis for planning new communities in the UK and abroad. Similarly, Zed concept is being applied to communities in the UK and China and spin-off products have developed. Thus, nationally and internationally a niche-regime is beginning to form, which directly emanates from the concepts developed in the original BedZed project (broadening). The niche-regime does demonstrate the potential for a range of societal innovations. However, there is no evidence for this broadening process leading to transformation.

The zero carbon concept is being applied to urban projects globally. The Zero Carbon Compendium 2015 (NHBC, Zero Carbon Hub and Architects, 2015) demonstrates international projects achieving zero carbon status, within cities, across every continent. Thus, the zero carbon concept is being applied across a range of geographical contexts, and is also beginning to create a new niche-regime.

5.3 The Vauban effect

Freiburg provides an example of where the local development regime has adapted as a result of a series of innovative movements and experiments (pressure for change), triggered (and sustained) by a series exogenous events (Whyl, Chernobyl, Fukishima and energy crises). Vauban was one of these experiments demonstrating the potential for a solar district (formation force) and developing the structures and practices needed to support it (support force).

Vauban is part of a local broadening process to adopt solar experiments (and sustainable urbanism) across Freiburg. Thus it is part of a solar niche-regime which has developed in the city (formation force). However, it has also transformed the local development regime, by altering structures and practices operating within the city.

The energy standards (adopted in Vauban) were applied by the planning authority to municipal sites across the city and the collaborative planning process was adopted to develop strategic and district plans (STELLs). This has led to wider community support for ecologically sustainable policies, infrastructure and services within the city and their inclusion in plans (interviews with planning officers and head of planning).

New institutions emerging from Vauban and Rieselfeld, provided vehicles for scaling-up low carbon experiments within Freiburg. Community fora, self-building groups, cohousing and community energy cooperatives enabled citizens to have greater control over planning decisions, the provision of housing and energy locally and provided the opportunity to choose low carbon development options. They also provided a platform for citizens to discuss future visions with all stakeholders and inform local plans; created networks for informal learning; structures through which projects could be funded and organised; and legal entities through which co-provision could be supported (interviews with planning officers, FESA e.V, Forum Vauban, GENOVA and Triangel).

The local energy company and federal government also played a role in the local transformation process. National and local subsidies for decentralised renewable energy (i.e. Federal feed-in tariff, Regiostrom tariff[12]) and the energetic refurbishment of existing building stock (i.e. KfW loans) enabled citizens to make significant investment in low carbon systems (interviews with Badenova, KfW Bank and Fesa e.V.). Contractual agreements for more energy efficient buildings imposed by the municipal planning authority on new developments and partial municipal ownership of the local energy company was used to ensure that energy efficient buildings and renewable energy systems were widespread in the city (interview with Head of Planning).

The Vauban experiment does not seem to have impacted on the development regime nationally or internationally, even though it is much visited.[13] There are various possible explanations. First, the aim of the experiment was to develop a model which was context appropriate and would scale-up within Freiburg, rather than inform development elsewhere (interview with the Head of Planning). Second, Vauban is a citizen-led model, involving co-provision, collaborative planning and production coops, which is simply incompatible with the development regime in many cities (interviews with planning

[12] To date 89 community renewable energy projects and 2000 citizen energy units have been funded by the Badenova Regiostrom Tariff, creating carbon savings of approximately 400,000 tonnes CO_2/annum (Badenova website, 2009).

[13] 25,000 trade visitors to Freiburg from around 45 nations every year (FWTM, 2013).

officers). Third, those involved in Vauban had an exceptional range of skills, expertise and motivation which were critical to the adoption of the vision and makes it difficult to replicate (interviews with planning officers and Forum Vauban, Sperling, 2002). Fourth, those involved were locally focussed and not integrated into the networks through which global dissemination would take place. The key players in Vauban did not have the motivation to market the concept further (interviews with GENOVA, Triangel and Forum Vauban). In reality it is no doubt a combination of all four.

The Freiburg solar industry has marketed itself globally through trade fairs. This has led to the diffusion of solar technologies and expertise, rather than the planning process, co-provision activities, new institutional structures and codes developed in Vauban. However, the solar city concept has gained some purchase internationally. For example after the 2010 trade fair in India a programme for solar cities was announced. However, the focus was on technology rather than other structural, cultural or practice innovations.

6. What moves and why?

So far we have consider each experiment as whole objects. Yet each experiment is composed of cultural, structural and practice innovations. These innovations seem to impact on the development regime differently and at a variety of scales. The scalar impact of each innovation can be traced (Table 4).

It seems all the cultural concepts introduced by the experiments have been integrated into the local development regime in which they are embedded (scale-up). SYMBIOCITY and the zero carbon concepts are also embedded in the national development regimes of the UK and Sweden (scale-up). All of the concepts are beginning to appear in international urban consultants tool-boxes, considered at least in the earlier stages of major development projects (interviews with SWECO, Tengbom, Urban Earth Consulting, WSP, Bioregional, Zedfactory, SKL, ARUP). Implementation internationally is sporadic but a broadening process is beginning at this scale, which could enable cities in different geographical contexts to co-produce appropriate working models.

Structurally, the more complex technologies (e.g. eco-cycle systems, energy- plus houses) have been tested in the development regime at all scales (broadened), but have not scaled-up. For environmental, economic, cultural and technical reasons, these technologies are often not suited to new geographical contexts, as demonstrated by the eco-cycles system in Chinese cities.

The codes developed for Vauban and BedZed have shown some success in scaling-up. The zero carbon standard began to transform the national development regime. Vauban's low energy codes are beginning to transform the local development regime. The zero carbon code is also being tested in a number of different geographical contexts to determine what models work (broadening).

New institutions for co-production integral to the provision of housing and energy in Vauban, have been integrated into the local development regime in Freiburg (scale-up). Indeed some are becoming more ubiquitous across Germany (e.g. community energy cooperatives) whilst others remain rare (e.g. self-build groups). These institutions play an important role in the delivery of solar districts, yet do not appear to be scaling-up internationally.

In terms of practice the experiments produced two new approaches to planning (collaborative and integrated systems planning); a new approach to managing decision-making processes (based on one-planet principles) and new lifestyle

Table 4
Scalar impacts of transition experiments on the development regime.

Innovation	Broadening			Scale-up		
	Local	National	International	Local	National	International
Cultural						
SYMBIOCITY concept			☑	☑	☑	
Zero carbon concept			☑	☑	☑	
Solar city concept			☑	☑		
One-planet concept		☑	☑	☑		
Structural						
Eco-cycles	☑	☑	☑			
Zed system	☑	☑	☑			
Energy plus homes	☑	☑	☑			
Solar technologies				☑	☑	☑
Low energy code				☑		
Zero carbon code			☑		☑	
Institutions for co-provision[a]				☑		
Practice						
Collaborative planning				☑		
Integrated systems planning			☑	☑	☑	
Co-provision				☑		
One planet lifestyle	☑	☑	☑			
One planet management principles		☑		☑		

[a] i.e. self-build, community energy coops, housing coops.

approaches (one-planet living and co-provision). Collaborative planning approach and co-provision have been integrated into the local development regime in Freiburg (local scale-up). But transaction costs are high (cost, time and engagement) for the local population (interviews with planning officers and Forum Vauban). Thus, practices are not applicable everywhere.

The integrated systems planning approach has been tested across cities in Sweden and is now adopted by Swedish municipalities and consultants in the strategic planning process (national scale-up). However, the Chinese example demonstrates that in new geographical contexts where approaches to governance and planning are very different, integrated systems planning maybe infeasible (SKL International interview).

One-planet management principles have been integrated into the local development regime in Sutton (local scale-up) and have been applied to other local authorities in the UK (broadening). One-planet lifestyles are also being tested in a range of different contexts (broadening). The successful application of both is very much dependent on the culture, structure and practices of the institutions or communities adopting them, although to an extent the one-planet framework can be manipulated to better reflect institutional and community goals (interview with Bioregional). Nevertheless it is not universally applicable in practice.

Overall, transition experiments clearly influence the local development regime in which they are embedded, culturally, structurally and in practice. The concepts, technologies, codes and some planning practices have scaled-up nationally. Internationally, cultural concepts are diffusing and eventually new, context appropriate, low carbon transition experiments may develop (broadening). However, structures and practices do not transfer well to new international contexts.

7. Conclusions

The research suggests that the impact of transition experiments on the development regime does vary significantly with scale. The innovative components, which are assembled in these experiments (cultural, structural and practices) also seem to have differing propensity to influence the development regime. They also interact differently with the development regime depending on scale. Thus, cultural innovations have a greater propensity to influence the development regime across all scales, whilst the structural and practice innovations tend to influence the development regime locally (Vauban-Freiburg; BedZed-Sutton) andnationally (BedZed—UK; Hammarby- Sweden). None of the experiments studied scale-up as whole entities.

Historical and geographical context shapes transition experiments. It also limits their potential for transformation. Time-lapses between experimentation and the introduction of support structures to enable transformation process (as demonstrated by the Hammarby experiment) is unlikely to lead to scaling-up. It is likely to result in the multiplication of experiments, tracking the changes in the landscape over time as seen in Swedish cities. The danger is, this will create an ever expanding (and increasingly diverse) niche-regime without producing a transition.

The transfer of an experiment to a new geographic location is likely to be equally problematic. For example, the Hammarby experiment has encountered difficulties diffusing to China, because the core “Swedish” principles underpinning the model (e.g. major public investment, city-wide infrastructural systems, co-production of solutions) are incompatible with the Chinese development regime. This means that entirely different models are needed for the Chinese context (not slightly modified ones).

Cultural concepts (OPL, Zero Carbon, SYMBIOCITY, solar city) can influence the development regime in different contexts, but need to produce new context-relevant development models if they are to be successful. Structures and practices (integrated planning approaches, eco-cycles, one-planet living) are more difficult to apply across historical and geographical contexts.

This view of context suggests that the importance of broadening in the transformation process (as suggested by the literature) has been overstated. Broadening within a geographic region and limited time-scale (i.e. within the same or very similar context) may have benefits for the transformation process (by finding optimal models), as innovations may be transferable and scalable. However, broadening across national boundaries and for prolonged periods, may well result in expanding niche regimes, which become increasingly diverse and unstable.

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