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Demonstration buildings as protected spaces for clean energy solutions – the case of solar building integration in Finland

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ABSTRACT

Demonstrations serve an important role in the promotion of sustainable technologies. This paper analyzes sustainable building demonstration from the strategic niche management perspective. It studies how demonstration sequences conducted over a long time span gradually contribute to niche development for clean energy technologies at the national level. Our empirical analysis focuses on solar building demonstrations in Finland, an unfavorable context for the technology. Our findings show that the demonstrations leveraged sporadic windows of opportunity for the technology resulting from international developments. The projects supported three niche development processes: the building of networks, different types of learning and the creation of visions and expectations, thereby softening the ground for solar technology uptake in new buildings. However, they have also struggled to make an immediate impact on mainstream practices due to weak continuity and the challenging socio-technical environment. The paper concludes with implications for carrying out demonstrations projects that provide continuity in unfriendly environments.

1. Introduction

Demonstrations serve an important role in the selection and diffusion of cleaner production solutions in general (Bai et al., 2014), and sustainable buildings and urban areas in particular (e.g. Iveroth et al., 2013; Zhang et al., 2012b). They can play several roles in the innovation process (Hendry et al., 2010a,b). They can serve as a "testing ground" to evaluate a technology for a particular application and identify the barriers to its deployment (Zhang et al., 2012a,b). At later stages, demonstrations can serve as "field trials" to improve performance and reduce costs before commercial rollout. The history of technology has also shown the importance of high-profile demonstrations for the public acceptance of new solutions (Lampel, 2001).

Yet there is evidence that green building demonstrations, in particular, often remain isolated and fail to spread solutions into mainstream (e.g. van Hal, 2000; Femenias, 2004; Rubino et al., 2007). In this paper, we ask whether they nonetheless make a difference for the uptake of *particular solutions demonstrated as part of the building*, especially for technologies that struggle to find other ways to breakthrough into mainstream markets. We suggest that demonstration may be important 'protected spaces' (Smith and Raven, 2012; Verhees et al., 2013) for emerging technologies, mobilizing future projects and bringing new practices into mainstream construction.

Our theoretical perspective draws on the concept of *strategic niche management* (SNM). A core assumption of the SNM approach is that the growth of promising new sustainable technologies can be facilitated by actively shaping technological niches, i.e. protected spaces that allow experimentation with the co-evolution of technology, user practices, and regulatory structures (Schot and Geels, 2008). Demonstration projects are central elements in such emerging niches. The current understanding in SNM is that in order to be successful and grow out of narrow use, niche innovations need to focus on several processes both within the niche community and outside it. These processes relate to the articulation of expectations, the building of social networks and several types of learning (Schot and Geels, 2008). However, there is little research yet on sequences of demonstration buildings and urban areas as protected spaces for individual cleaner technologies.

In particular, we focus on demonstration projects conducted in unfavorable environments where geographical conditions and a

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lacking policy support hinder the diffusion of cleaner technologies. This has been the case for solar heat and power in Finland. Our paper examines major demonstration sequences in Finland since the 1980s integrating solar heat and/or power into buildings and urban areas. We analyze the impact of demonstrations on (a) niche internal processes (i.e., learning, community building and alignment of expectations) and (b) niche external processes (relations to existing beliefs, practices and power bases outside the niche). By assessing the successes, failures and cumulative effects of these projects, we identify implications for clean energy entrepreneurs and technology funding agencies. We highlight the importance of demonstrations in learning among the parties involved in key tasks in technology deployment, such as commissioning, maintenance and operations. Moreover, we suggest that demonstrations are necessary, but not sufficient for the mainstreaming of cleaner energy solutions such as solar heat and power. In addition to demonstrations, external pressures are needed to generate the impetus for mainstreaming.

The following section presents the theoretical framework for our analysis, whereas Section 3 presents the date and methods employed. Section 4 offers an analysis of niche creation processes in demonstrations of building-integrated solar energy in Finland over four decades. Section 5 discusses the findings across cases and Section 6 presents the conclusions.

2. Theoretical framework: strategic niche management and the role of demonstrations

In strategic niche management (SNM), technological niches refer to 'protected spaces' that allow the testing of new alternatives and the mutual articulation of technology, demand and broader societal issues such as sustainable development (Schot and Geels, 2008; Kemp et al., 1998). Governments may protect niches in order to nurture and protect sustainable innovations that are not yet competitive but are deemed important for the future. Technological niches are not yet market niches, but can grow into market niches if successful. According to Geels and Kemp (2012) experimental projects like demonstrations may strengthen a niche by allowing niche actors to learn about innovation in real-life circumstances and develop a community with shared problem agendas for the technology.

2.1. Niche development through niche internal and niche external processes

Early SNM work argued that the success of niches depends on three *niche-internal processes*: i) the articulation of *visions and expectations* ii) the development and alignment of social *networks* of stakeholders supporting the innovation and iii) *learning* about the technological, economic, cultural and societal aspects concerning the emerging niche (Schot and Geels, 2008). For visions and expectations to be helpful, they should be shared by many actors, be specific enough to give guidance, and their content should be substantiated by ongoing projects. In terms of networks, it is important that they are broad and involve outsiders, thus allowing the widening of cognitive frames. Networks should also be 'deep' in the sense that they mobilize commitment and resources, including political influence (Heiskanen et al., 2011). Learning processes are thought to contribute to niche development if learning is not merely about the accumulation of information but also about the evolution of cognitive frames and assumptions, i.e. second-order learning.

Table 1 summarizes literature on the niche internal processes and angles to their investigation (Schot and Geels, 2008).

Besides the importance of the niche-internal processes, studies have also directed attention to niche-external processes like 'niche–regime interactions' in sustainability transitions (Schot and Geels, 2008). Niche–regime interactions refer to whether niches manage to challenge or change regimes, i.e. established industries with their own rules, roles and activities. Examples of regimes include the energy system and the construction and real estate industry. Regimes have been built up over several decades and they are usually very resistant to change. From a socio-technical systems perspective, regime actors encompass social groups like businesses and scientists but also policy makers and users (e.g. Bijker, 1995).

Originally, SNM scholars regarded change as a bottom-up process where niches grow and become empowered gradually, so as to challenge the regime (Schot and Geels, 2008). Later on, the multi-level perspective by Geels (2002) created a broader understanding of transitions towards sustainability. While niches form the micro-level of emerging innovations, regimes represent the meso-level accounting for the stability of existing large-scale systems. Finally, the socio-technical landscape level refers to deep structural trends such as climate change and the availability of energy resources. It is the interactions between the different levels that eventually determine the unfolding of sustainability transitions. Niche innovations are important but they need to align with other processes to gain momentum. When windows of opportunity arise and the regime is destabilized, niche innovations that are strong enough can challenge the regime.

Later research has identified other transition pathways besides confrontations between niches and regimes. Niche innovations change regimes for example by being adopted in the regime from the start to solve certain problems (Raven, 2006) and by translating niche experiences to the regime (Smith, 2007). Niche innovations can also change regimes via symbiotic relationships or cumulative adjustments (Geels and Schot, 2007); they can be incorporated into existing regimes or transform the relations between existing regimes (Raven and Verbong, 2007) (Table 2).

2.2. Demonstration projects and niche development

Demonstration products and projects are thought to be critical for radical new technologies, such as solar technology in non-established markets. Demonstrations may reduce uncertainty related to technological performance, product standards, uptake by potential markets and commercialization (Harborne et al., 2007). However, there is evidence that building demonstration projects often remain isolated and fail to spread solutions into the mainstream (e.g. van Hal, 2000; Femenias, 2004; Rubino et al., 2007). Often, this is attributed to a lack of monitoring, evaluation and information transfer (van Hal, 2000), which in SNM terms equal the development of a shared knowledge base and a set of rules in the niche community (Raven et al., 2008).

The SNM literature regards niche creation to unfold at two levels: local projects and the global niche (Van Mierlo, 2012; Geels and Raven, 2006). It argues that "sequences of local projects [such as demonstrations] may gradually add up to an emerging field at the global niche level" (Schot and Geels, 2008, 543). Hence, a particularly interesting question is how sequences of local projects conducted over a longer time span can gradually develop into patterns and arrangements that facilitate the mainstreaming of the technology.

Research on demonstration projects suggests that demonstrations are useful for (i) learning, (ii) opening a market through increased customer awareness and removing institutional barriers and (iii) forming a network of actors to drive technology and policy change (Harborne et al. 2007). Hendry et al. (2010a) have distinguished between the demonstration types of *test version*, *field trial*