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User innovation in sustainable home energy technologies

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HIGHLIGHTS

- We clarify how citizen users are able to invent in home heating systems.
- We researched inventions that users did to heat pump and wood pellet burning systems.
- During the years 2005–2012 there were 192 inventions by users in Finland alone.
- Users were able to invent in practically all subsystems of these technologies.
- Users' ability merits policy attention and can lead to new types of policy action.

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ABSTRACT

The new millennium has marked an increasing interest in citizens as energy end-users. While much hope has been placed on more active energy users, it has remained less clear what citizens can and are willing to do. We charted user inventions in heat pump and wood pellet burning systems in Finland in years 2005–2012. In total we found 192 inventions or modifications that improved either the efficiency, suitability, usability, maintenance or price of the heat pump or pellet systems, as evaluated by domain experts. Our analysis clarifies that users are able to successfully modify, improve and redesign next to all subsystems in these technologies. It appears that supplier models do not cater sufficiently for the variation in users' homes, which leaves unexplored design space for users to focus on. The inventive users can speed up the development and proliferation of distributed renewable energy technologies both through their alternative designs as well as through the advanced peer support they provide in popular user run Internet forums related to the purchase, use and maintenance of these technologies. There are several implications for how such users can be of benefit to energy and climate policy as well as how to support them.

1. Introduction

The new millennium has marked an increasing interest in citizens as energy end-users. Efforts at climate change mitigation have led to public campaigns to curb citizen energy use and to incentives for the uptake of renewable energy technologies. The coming of two-way electricity metering and distributed energy production have widened the traditionally passive array of roles set for citizen users of centralized energy supply. While much hope has been laid on more active citizen energy users, it has remained less clear what they can and are willing to do.

Our research on user inventions in heat pump and wood pellet technologies in Finland revealed next to 200 user inventions and clarifies that citizens are both able and willing to invent improvements to renewable energy technologies. In the course of this paper we seek to clarify what, where and how significantly users can modify and invent renewable energy technologies in residential homes. This scrutiny helps to counteract the false assumption that users can make only low-tech add-ons as well as the equally untenable hope that citizen users could take over the design of renewables all together if only given the chance and incentivized properly. The findings position renewable energy users amidst the high variation found in user inventiveness in other fields, ranging from next to no invention to, for instance, close to one fifth of mountain bikers within a small region reporting to have modified some of their equipment (von Hippel, 2005, 20).

Our focus on Finland is motivated by three contextual issues that render the country "a hard case", a neutral or even hostile a context, for user innovation in the renewable home heating technologies we examine. First, Finland has only a few small manufacturers of heat pump and pellet burning technologies and there are virtually no supplier ecologies that could spur user

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inventiveness. Second, wide availability of district heating systems and low energy and electricity price backed by recent pro nuclear power decisions lessen economic incentives to invent in renewable home heating systems.[3] Third, there is little citizen advocacy or renewable energy activism that could explain user inventiveness (Ornetzeder and Rohracher, 2006).

Heat pumps and wood pellet systems are both relatively new renewable home energy technologies in Finland as they have proliferated only after the turn of the millennium. Air source heat pumps have proliferated widely, and the current stock of 400,000 installations in 5,4 million people country contributes to lowering the amount of electricity consumed in the over half of Finnish housing stock that is heated with electricity. Ground source heat pumps and Pellet burning systems have had more modest proliferation; by 2012 producers estimate 60,000 and 25,000 home units, respectively. Significance of ground source heat pumps and pellet burning systems lies in offering an alternative for oil heating, particularly through converting from old oil central heating to renewable heating.

Our article is structured as follows. We first present literature review and method sections. We then examine what users are inventing in sustainable energy technologies and examine where in the technical systems users are able to invent and what issues appear to channel or curb users inventive actions (Section 4). We then focus on the potential in user inventions in expert evaluation (Section 5). These analyses are followed by a discussion and implications for energy and climate policy.

2. Active and inventive users of renewable energy technologies

To date the dominant approach to citizen energy end users has rested on the technology transfer view, which posits a linear flow of knowledge from research and development to everyday life. Technological improvements are seen to emanate from research laboratories and find their way to end consumers via suppliers, retailers, assemblers, maintenance providers and promotional agencies (Guy and Shove, 2000). In this scheme of things consumer attitudes and perceptions of technology act as predictors of users adoption (Rogers, 1995; Faiers and Neame, 2006; Schweizer-Ries, 2008) and the key issue becomes how to overcome the 'social' or 'non-technical' barriers, seen as the main obstacles to the flow of adequate energy technology and knowledge into practice (Shove, 1998; Garrett and Koontz, 2008).

There is, however, accumulating evidence that complicates this view. Since the late 1970s, sociological and demographic research on residential energy use has consistently found great variations in energy use among similar households (Lutzenhiser, 1993; Guerin et al., 2000). These variations do not result from technological differences (different heating systems, different insulation) but from behavioral differences in using products and systems (thermostat settings, number and length of showering, leaving lights on etc.). However, rather than following straightforwardly from energy attitudes or diligence in adopting, many differences appear to follow from how end users adopt and adapt the technologies to their local conditions and the particularities of their houses and everyday practices (Shove et al., 2007; Caird and Roy, 2008). The importance of skillful adoption and finding a well-suited blend of appropriate technology options and energy practices has thus been raised to the fore (Walker and Cass, 2007; Raven et al., 2008) as have activities and skills in DIY house and energy efficiency renovations (Shove et al., 2007). "Grassroots innovation" has recently been underscored as means to capitalize on these "innovations-in-practice" and suggested to contribute to their persistence and proliferation potential (Seyfang, 2009; Heiskanen and Lovio, 2010; Moloney et al., 2010). Varying social and cultural conditions thus do not appear to be mere 'barriers' to diffusion, but citizen activities related to technological adaptation and improvement as well as to market creation can become key 'enablers' of proliferation and more effective use of heating solutions.

An important line of research within the above avenue is to examine users capacity and willingness to invent, design and supply their own technical solutions. Contrary to the technology transfer view users in many other walks of life have been documented to develop technology on their own. There are dramatic field and timing specific variations. The proportion of user innovations can vary from next to none to up to 80% found in surgical instruments and be limited to pre-commercial stage of innovation or include users growing into manufacturers or continued development in longstanding user innovation communities (von Hippel, 2005; Baldwin et al., 2006). Inventions by users tend to be highly concentrated on few user inventors, typically representing less than 0.1% of total user population. However, a greater number of users do some modification to some of their equipment, for instance surveys targeted at households in the UK indicated that 6% of users have modified some technology they use during the last three years (von Hippel et al., 2010).

Within research on renewable energy, user innovation has been documented to occur in studies on modern biomass heating systems and solar collectors in Austria (Ornetzeder and Rohracher, 2006), wind turbine cooperatives in Denmark (Jørgensen and Karnøe, 1995; Karnøe, 1996), energy efficient buildings in Germany (Ornetzeder and Rohracher, 2006), and straw bale housing in the US (Seyfang, 2009). These studies indicate the significance of user innovation in the contexts inspected, and imply that the issue may deserve further attention. In particular a more detailed examination of users' inventions is interesting. The present inquiry thus seeks to examine in-detail where in the technical system in question inventive user modifications are accomplished and where not. This provides indications to how capable the inventive users are at their technical modifications of renewable home-heating technologies. This should provide further cues of what role their advice and other help they provide to other users may play in the market creation for renewable heating technologies. This latter interest is motivated by the popularity of Internet forums dedicated to renewable home heating technologies, for instance, the Finnish ones related to the three technologies we examine have been loaded 60–80 million times during the last 5 years, and they are arguably among the key enabling factors for the proliferation of these technologies.

3. Data and methods

Our data set consists of the analysis of Finnish heat-pump and wood pellet Internet forums, where inventive users display their projects, and 40 in-depth interviews. These user run Internet forums have evolved into major communications medium amongst the users of these heating technologies. The main Finnish heat pump forum www.lampopumput.info features over 208,000 posts and 13,000 discussion threads by over 4100 registered discussants in its 6 years of its existence. By November 2012 its pages had been viewed 55,374,899 times, which is fairly much for a language group of about 5.5 million Finnish speakers and installed base of 400,000 units at the end of the 6 year period.

[3] There are three nuclear plant projects underway in Finland. The construction of 1600 MW nuclear plant (Olkiluoto 3) started in 2005. Current estimate for opening the plant is 2015. In 2010 Finnish government made a decision to allow two new nuclear plants (Olkiluoto 4 and Fennovoima) to be built. The lower energy and electricity price expectation does not directly affect users' incentives to self-build cheaper renewable systems, but it does affect incentives to render them more efficient and economic incentives to invest in renewables in the first place.