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Innovation-enabling policy and regime transformation towards increased energy efficiency: the case of the circulator pump industry in Europe

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ABSTRACT

When new energy efficient products are struggling with their commercialisation and diffusion into widespread applications you would typically expect policy-makers and green lead-users to guide the way. This paper examines the case of the hot water circulator pump industry in Europe, where parts of the industry envisioned and worked for a voluntary energy label, bringing technological innovation, new business and energy savings of approx. 85% for each new circulator pump. The case study explores the complexities of innovation processes where technology, market, actors and policy co-evolve over time to transform an existing socio-technical regime. The paper highlights the importance of policies to reduce barriers towards innovation and energy efficiency and shows that it is not always policy-makers that establish the crucial policies that change the innovation dynamics for the benefit of the environment and the industry.

1. Introduction

Sustainable energy systems in the future will require change in the way energy is both produced and used. On the consumption side the load on the energy system must be lowered either through energy conservation or through increased energy efficiency (IEA, 2012).

Achieving energy savings through increased energy efficiency is, however, difficult. There are in practice multiple barriers towards energy efficiency (Hirst and Brown, 1990; Reddy, 1991; Weber, 1997; Sorrell, 2004) whether related to institutional (Lovins, 1992), market and economic (Jaffe and Stavins, 1994) or organisational aspects. These barriers seem present in some way or another for any kind of energy efficient product, reducing the likelihood of the product actually leading to energy savings (Sorrell, 2004). The literature does, however, also provide a few examples of how these barriers are overcome, primarily through various forms of public policy instruments (Sorrell, 2004; Farinelli et al., 2005). What are not present in the current literature are elaborate empirical accounts of how energy efficient products are developed and diffused while among other things are being influenced by public policy. This paper will cover a complete innovation process through the case of the energy efficient circulator pump[1] in Europe – see a typical hot water circulator pump in Fig. 1.

In Europe alone, hot water circulator pumps for heating systems are estimated to use approx. 53.2 TWh electricity per year (AEA Energy and Environment, 2008) for an estimated stock of 140 million including both standalone and boiler-integrated circulators.[2] Even though these figures are quite substantial there has been little awareness of the energy consumption and related potential savings for circulators among house owners, tenants, professionals and policy-makers. As circulators are somewhat hidden in homes and apartment blocks most house owners or tenants are not aware of having one. The barriers towards energy efficiency are therefore well established for this type of product (Sorrell, 2004).

Technological development has however led to breakthroughs in electric motor efficiency, motor control systems and circulator housing through the 1980s and 1990s. Combined, these developments have had tremendous impact on the overall energy

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[1] The terms notation pump, circulator and circulator pump will be used interchangeably and refer to the same product.

[2] The circulator manufacturers see themselves as part of the overall pump industry and suppliers to the heater/boiler manufacturers.

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Fig. 1. A typical household circulation pump (Smedegaard).

efficiency of the circulators. Typically switching from a "conventional" circulator (D-rated or worse) to a state-of-the-art circulator (A-rated or better) means an approx. 85% reduction in yearly energy use (AEA Energy and Environment, 2008). In this innovation journey, technological development, economic growth and energy conservation efforts co-occur. The development is by no means a linear innovation process where one activity inevitably leads to the next (Garud et al., 2013), which is why this paper uses an evolutionary perspective on innovation processes and systemic change (Nelson and Winter, 1982; Kline and Rosenberg, 1986). The paper will untangle these complex processes and describe how the co-evolution of energy efficiency, technological development, policy and innovation actually occurred – something that is rarely studied in depth in the current scientific literature.

The paper is structured as follows. A short literature review will highlight the characteristics of energy efficiency and innovation to identify gaps in the current knowledge. Following, there is a brief section on the theory of innovation and socio-technical systems to establish the paper's theoretical foundations. The research methodology applied in the paper will then be explained. The main emphasis of the paper is on the comprehensive empirical case study after which the paper will end with discussion, conclusion and policy implications.

2. Challenges of energy efficiency innovation and the role of policy

The commercialisation and diffusion (Shama, 1983; Rogers, 2003) of energy efficient versions of existing products is a challenge. Despite the direct economic and environmental benefits of energy efficiency, new energy efficient products are struggling on the market. This challenge is attributed to a series of economic, behavioural and organisational barriers that are hindering the diffusion and use of energy saving technologies (Hirst and Brown, 1990; Reddy, 1991; Weber, 1997; Sorrell, 2004).

Most of the literature on barriers towards energy efficiency has its focus on market failures owing to the products' inability to compete with conventional products on the market, owing to higher capital cost and inability to value lower lifecycle cost (DeCanio, 1998; Sorrell, 2004). The consensus is that public policies are needed to overcome these barriers in order to achieve market transformation (Birner and Martinot, 2005; Foxon and Pearson, 2008; Montalvo, 2008).

2.1. Policy instruments and their impact

Three generic types of specific policy instrument are usually put in place to overcome barriers towards energy efficiency (Sorrell, 2004; Farinelli et al., 2005). Through normative, informative and economic policies (Togeby et al., 2009) or a combination of all three, energy efficient products are to some extent able to succeed on the market, overcoming barriers such as risk, hidden cost, access to capital, split incentives, imperfect information and bounded rationality (Sorrell, 2004; Foxon and Pearson, 2008). These policies are often designed to target where the barriers are located, so it could be with the producers, the consumers or elsewhere.

As increasing energy efficiency in most cases is a directed action towards saving energy, there is often a strong emphasis on focus areas or impact areas when developing policies. These areas are typically chosen because their consumption is high or because the savings are relatively easy and cost-effective. This is for instance seen in IEA's policy recommendations with the focus areas of cross-sectoral, buildings, appliances and equipment, lighting, transport, industry and energy utilities (IEA, 2014).

This paper will primarily focus on product-level policies although these should be seen in relation to cross-sectoral energy saving policies and taxes. A complete overview of policy options can be found in existing literature (Hirst and Brown, 1990; Thiruchelvam et al., 2003; Sorrell, 2004).

Energy labels are seen as one of the primary ways of supporting energy efficiency directly at the product level. Using product energy labels is a way of supporting rational consumer choice and overcoming the barriers of imperfect information and bounded rationality. These efforts are often mandatory but can also be voluntary (Krarup and Ramesohl, 2002).

Energy labels are usually directed at changing end-user behaviour and were first seen in use in domestic goods and white goods in the early 1990s (Bertoldi et al., 1999). Within these product categories certain successes have been seen owing to the implementation of product energy labels, but these cannot be seen as isolated policies as markets, areas and countries differ greatly (Boardman, 2004).

Product labels are not necessarily a sure path to the diffusion of more energy efficient products so stricter regulation forms could be more efficient in some cases (Colombier and Menanteau, 1997). These typically come in the form of Minimum Energy Performance Standards (MEPS) or appliance standards (Gillingham et al., 2006) which accelerate the market process by demanding a certain level of efficiency (4E – IEA, 2012). The use of stricter regulation types such as MEPS in combination with other policies is regarded as necessary to support the transformation of existing markets (Geller and Nadel, 1994; Nadel and Geller, 1996; Bertoldi et al., 1999; Birner and Martinot, 2005). When implementing energy savings through increased energy efficiency direct and in-direct rebound effects can have an impact on the actual reduction of the consumption (Greening et al., 2000; Herring and Roy, 2007; Sorrell, 2007). These effects are, however, often overestimated (Gillingham et al., 2013) and in this particular case do not seem to play a large role.

The experiences in OECD countries have been summarized by Geller et al. (2006) and they concluded in their cross-going analysis that policies can lead to substantial energy savings. Minimum efficiency and strict regulation programmes can be effective especially if they are continuously updated to fit the product and its development pace. Furthermore, the authors found that government funded R&D can help lower the risks and accelerate the innovation pace. Recent work (Gillingham et al., 2009) supports the majority of these findings, but adds a crucial point concerning the lack of empirical data that in general limits this kind of analysis.

Gann et al. (2010) discuss whether performance standards at the buildings level or prescriptive standards at the product level are encouraging innovation. They argue that performance standards, which pose demands at the building level but don't choose technologies, are best at encouraging systemic innovation, whereas prescriptive standards encourage product innovation at the building component level. Their work clearly point to the complexity of