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Passive House at the crossroads: The past and the present of a voluntary standard that managed to bridge the energy efficiency gap

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HIGHLIGHTS

- We present the Passive House (PH) as example of technological innovation.
- The developers of PH managed to overcome the barriers to energy efficiency.
- Successful innovation is more than good technology.
- The heterogeneity of adopters of PH is growing.
- The future of PH: the tension between rigid control and flexible adaptability.

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ABSTRACT

Improving energy efficiency in dwellings is generally seen as the low-hanging fruit of climate change mitigation. In particular decreased heat loss through better insulation is suggested as one of the most cost-effective means to achieve the ambitious national and international goals of climate gas reduction. However, the literature shows that a profitable technological solution is not sufficient to reach the energy goals. Aspects such as a lack of information, unobserved costs, and heterogeneity among users can compromise the success of technical innovation. Still, there are successful concepts that drive the technological development in the construction sector. The Passive House is an example for such innovations that manage to bridge the energy efficiency gap. This paper addresses the Passive House concept and standard as a success story of technological innovation. With Bruno Latour's *Science in Action* (1987) as a starting point, we describe the conditions under which the standard was created, the role of the network built around the Passive House Institute, and the consequences of exporting the standard. We identify success factors that have supported the diffusion of the Passive House standard and concept and discuss its possible development in the current situation which is characterized by its wide-spread adoption.

1. Introduction

Reducing buildings' energy consumption is generally seen as the low-hanging fruit of climate change mitigation (IPCC 2007). In particular decreased heat loss through better insulation is suggested as one of the most cost-effective means to achieve the ambitious national and international goals of climate gas reduction (McKinsey and Company, 2009). However, that the large potential of these measures is still promoted today should suggest caution: the benefits of better insulation have existed and have been well understood for years (e.g., Perlman and Warren, 1977) but have apparently not lived up to their potential. The list of factors that are able to explain this classic case of an energy efficiency paradox is long, including the lack of information and private information costs, principal/agent slippage, unobserved costs, and heterogeneity among users (Jaffe and Stavins, 1994); sociocultural and psychological factors (Wilk and Wilhite, 1985); and the strategic postponing of costly investments (van Soest and Bulte, 2001).

Although all of these factors explaining the lack of energy efficiency investments apply to the case of buildings and building insulation, there is a counterexample of a building type that goes far beyond the usual measures to avoid heat loss: due to an innovative recombination of existing energy efficiency measures and the development of building elements, the Passive House concept allows a comfortable indoor temperature even without an

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active heating or cooling (hence the name "passive"). In practice, most Passive Houses have an active heating but still with radically reduced energy demand. At the end of 2010, there were approximately 27,600 certified Passive Houses in Europe, and it is estimated that there will be approximately 65,000 such houses by the end of 2012 (www.pass-net.net). The increase in the number of projects has been exponential since the first Passive House was built in Darmstadt, Germany, in 1991. Reducing the heating needs of buildings by a factor of 10, the Passive House requirements are considered by many experts today as a precondition to the "nearly zero energy building" that, according to the EU directive on the energy performance of buildings (EPBD), must be implemented by all new buildings by the end of 2020 in the EU Member States.

This is a remarkable success story, given that the diffusion of the concept was initially mainly and is still mostly driven by enthusiastic individuals. The success is not only measurable in the number of dwellings built in accordance with the voluntary Passive House standard, but also in the attention that the Passive House enjoys in Europe and beyond.

In this paper, we describe how this voluntary standard could become so widespread. To identify the critical success factors in this history, we have analyzed insider accounts, observed a major Passive House conference and studied relevant documents. However, before we reconstruct the history from these sources, we will present a brief overview of what is known from the literature about barriers to otherwise rational energy efficiency measures. This overview will then guide us in the interpretation of success factors in the Passive House story.

2. Factors explaining the energy efficiency paradox

Explanations for the lack of seemingly rational investments in energy efficiency measures such as improved insulation each refers to its own general theory of human agency.

In this context, economic frameworks dominate. They introduce additional factors that influence the relationship between actors (potential investors) and their actions (investment energy efficiency) and thus help to make the outcome predictable. These "barriers" have been categorized along several axes, for instance, as being institutional, market related and behavioral (Weber, 1997). Jaffe and Stavins (1994) describe market failures such as the lack of information, principal/agent slippage (investments made by those who are not paying the energy bills, e.g., "landlords versus tenants"; see Phillips, 2012), and existing subsidies keeping energy prices artificially low. That these factors are described as "failures" implies that they should be corrected to create a perfect market. However, even if information about energy efficiency savings were perfectly transparent, if investors could withdraw the profits directly and if there were no distortion through subsidies, according to Jaffe and Stavins (1994), non-market failures would still interfere. The authors mention private information costs (an individual's effort to learn new things) and heterogeneity among potential adopters (affecting the desirability of technological adoption, e.g., climatic variation). As a final non-market-related factor, they describe uncertainty about future energy prices. This point was generalized by van Soest and Bulte (2001), who demonstrated that the strategic postponement of costly and irreversible investments may be rational, given the problem that technological progress does not follow easily predictable linear paths (see also Sørensen et al., 2000).

A common motive in critiques of economic approaches to the energy efficiency paradox is that they hide or at least do not account for their own normative foundations (Weber, 1997). As early as 1985, Wilk and Wilhite described the rationality of *not* investing in home insulation that is revealed if competing normative goals that are particularly abundant only in domestic settings are taken seriously (see, e.g., Aune, 2007). Extending this perspective, Shove (1998) reminded us that the individuals involved in (not) making energy-efficient choices are creative social agents embedded in a broad variety of technical, social and cultural contexts that have to be accounted for if these (non) investments are studied.

In this paper, we assume that taken together, the economic, technical, social and cultural explanations for non-investments in energy efficiency all contribute to a better understanding of why people do not invest in energy efficiency. However, instead of trying to integrate these explanations into one all-encompassing system (as proposed by Chai and Yeo, 2012), we follow actors who have overcome most of these barriers and describe how they have dealt with them. As we will show in our description of the Passive House concept and standard, this is a story of a vigorous fight against consequences of market failures, lack of information, technological and economic uncertainty, and competing norms. We will argue further that in the current situation, in which the diffusion of Passive Houses reaches new quantitative dimensions, one of the challenges described in the literature, the heterogeneity among adopters will become crucial.

3. Method

This paper is the result of a structural analysis of in-depth interviews with key actors in the Passive House scene, participant observation at the 15th International Passive House Conference in 2011, and document analysis. This multi-method approach helped us to follow the key actors in various situations: being challenged to talk about their work and about Passive Houses generally, communicating with colleagues and promoting the technological solutions developed by industry partners, and presenting the concept through the World Wide Web to mobilise possible actors and convince possible customers. Moving between these situations, the actors adapt the language and the arguments to the listener. In all cases, they are promoting the Passive House as a robust concept, although the way they communicate the message is malleable.

The four in-depth interviews took place in Germany in June and July 2011 and lasted between 1.5 and 3 hours. The interviewees were key actors in the Passive House scene, and their answers offered a competent yet partial evaluation of the development of the concept. Two of the interviewees, a physicist (DB) and an architect (DA), were employed by the Passive House Institute (PHI), whereas the other two are involved in product development (DC) and in the design of Passive Houses and renovations of old buildings to Passive House standard (DD). The last two interviewees have been involved in Passive House projects from an early stage and have been active in developing new products, respectively new architectural solutions over the years.

The 4-day 15th International Conference held in Innsbruck, Austria, in 2011, offered a sample of how the Passive House concept and standard are communicated publicly. The thematic sessions of the conference were accompanied by exhibitions of certified components, poster sessions, and visits to Passive House projects. The social events allowed participants to meet and discuss the topic, strengthening the links between actors. The newcomers were presented to the audience, and their projects were publicly encouraged. The participation at the event offered the opportunity to follow the participants as actors in the network and to observe how they communicate and interact. The visits to Passive House projects in the region of Vorarlberg allowed the architects to present their work as a success story and to talk about