Chapter 8

The users of the technology: the case of solar PV in the Netherlands

Véronique Vasseur and René Kemp

Abstract

This chapter contributes an empirical analysis of the role of users in the adoption of solar photovoltaic (PV) systems. It first concentrates on individual decisions which lead to an adoption decision regarding solar PV, before turning to diffusion processes. We examine the empirical literature on the adoption of solar PV and present the results of our empirical analysis – based on a questionnaire completed by 817 Dutch households. We find that the slow adoption and diffusion of solar PV is not driven by single factors such as price or technology change, but typically involves co-evolution between multiple developments. It is related to consumer preferences, product offerings, and slow introduction of policies to promote the use of renewables. We show that knowledge about solar PV is an important factor underlying the adoption or non-adoption of PV in the Netherlands.

8.1 Introduction

Solar energy has a large technological potential that allows it to become one of the main sources of renewable energy in the long-term future (Gostelie, Maas et al. 2010). Solar PV is a technology that is well-known to the public, but its diffusion has been slow, despite governmental support programmes. This chapter contributes to the literature on socio-technical transitions and that on technological innovation systems by offering an empirical analysis of the role of users in the adoption of solar PV systems, and applies a systems perspective to the literature on diffusion and adoption. The former category of literature describes how new technologies emerge within more or less protected niches, and how they turn into configurations that shape and reshape regimes (e.g. Geels, Kemp, Rotmans). The latter, that of technological innovation studies, focuses on the structure of the system (actors, institutions, and networks) and on the key processes that take place within a system. These processes contribute to the build-up of a technological innovation system and thereby to the successful development, diffusion, and utilisation of the emerging technology (e.g. Hekkert, Negro, Bergek). It is motivated by the observation that these studies give little attention to actual adoption decisions by people. To this end, we introduce the literature on adoption and diffusion of innovations.

The process of adopting innovations has been studied for over 30 years, and one of the most popular adoption models was described by Rogers in his book “Diffusion of Innovations“. For Rogers (2003), adoption is a decision of “full use of an innovation as the best course of action available” and rejection is a decision “not to adopt an innovation” (p177). Rogers defines diffusion as “the process in which an innovation is communicated thorough certain channels over time among the members of a social system” (p5). For Rogers, innovation, communication channels, time, and social system are the four key components of the diffusion of innovations.

Adoption is the outcome of an information-processing process resulting in the active or passive acceptance of an innovation. Diffusion is the dissemination of an innovation within a social system. Diffusion theory focuses on how quickly and to what degree a social system accepts an innovation. Although a certain degree of overlap between these concepts may exist, adoption analysis often takes characteristics (of the individual, the innovation, as well as contextual) into account (at a disaggregate level) while diffusion analysis does not, or only to a very small degree (aggregate level).

Thus, diffusion is the result of all the adoption decisions, so an understanding of adoption processes is paramount in attempts to gain more insight into diffusion processes. Adoption decisions drive every diffusion process, and this chapter concentrates on individual decisions which lead to an adoption decision regarding solar PV, before turning to diffusion processes. Although many studies have examined the adoption and diffusion of solar PV, few of them deal with solar energy from a consumer behaviour perspective.

In the following section we examine the empirical literature on adoption of solar PV, and then present the results of our empirical analysis – based on a questionnaire completed by 817 Dutch households. This section also describes how our findings compare to those of others

8.2 Findings in solar energy adoption and diffusion studies

Thomas Sparrow was the first researcher to focus primarily on the decision to purchase solar energy systems. In a study of 45 owner-users of solar custom homes located throughout the United States in 1977, he considered various socio-economic factors involved in the adoption of solar-energy technologies. Sparrow emphasised that there are region-specific differences in consumer attitudes as well as in the factors that are important for those adopting solar energy systems in different geographical regions.

However, his small and geographically diverse sample presents difficulties (Labay and Kinnear 1981). Another study conducted in the United States was undertaken by Cesta and Decker (1978) to identify and measure the attitudes of the public, including consumers. A two-stage Delphi research study identified some factors that may either inhibit or stimulate solar energy adoption and commercialisation. The following factors were found to be important: product cost, lack of product knowledge, lack of governmental support, and public concern over the energy crisis. Cesta and Decker also found that governmental and business actions could help to initiate more solar energy use and developmental efforts (Cesta and Decker 1978).

Several researchers used Rogers' diffusion of innovation theory as their theoretical framework. Labay and Kinnear (1981) used the theory to examine the purchase decision process for residential solar energy systems in one geographical region, the State of Maine. They used multivariate nominal scale analysis to develop classification models based on both attribute perceptions of solar energy systems and demographic characteristics. They discovered that attribute perception data afford somewhat greater classification potential than demographic data. An important aspect in the work of Labay and Kinnear is the inclusion of knowledgeable non-adopters as a group worthy of attention, in addition to adopters and unaware non-adopters. They argued that the knowledgeable non-adopters attached greater value to the product and economic factors (e.g. the quality of the system and the payback period) (Labay and Kinnear 1981), indicating the potential for adoption. Research by Kaplan (1999) also used Rogers' diffusion of innovation theory to investigate why utilities do not adopt solar power, and what might help encourage their interest. They found that motivation, experience, and familiarity (e.g. whether a household has previously installed a similar technology, such as solar heating) are important variables which can influence the interest in solar PV. These findings have significant implications for commercialisation efforts, as well as for the management of utility operations. Kaplan emphasised that small wins, experimentation, and groping along can achieve far more effective diffusion of solar power, with far greater ultimate success, than is expected from the conventional wisdom of large-scale research and development (Kaplan 1999). The study conducted by Faiers and Neame (2006), using householders in central England as a case, also applied Rogers' theory to investigate householders' attitudes towards characteristics of solar systems, and identified some of the barriers to adoption. They surveyed a group of "early adopters" and a group of presumed "early majority" adopters of solar power, and the overall results show that, although the "early majority" demonstrates a positive perception of the environmental characteristics of solar power, its financial, economic, and aesthetic characteristics are limiting adoption (Faiers and Neame 2006). In other words, the actual cost of an innovation is relatively unimportant; what matters is what it is worth to the adopters as individuals. Jager (2006) studied factors that lead to a faster diffusion of solar PV in society from a behavioural perspective. He discussed different consumer motives within a framework of underlying needs and the time sensitivity of various outcomes. Financial support and general problem awareness were found to be critical motives (which can also be seen as 'facilitating factors') in the city of Groningen, but the positive effects of information meetings, technical support meetings, and social networks were also identified. In terms of the factors affecting the speed and degree of diffusion (Rogers 1995), these meetings reduced the complexity of the decision problem as experienced by the buyers (Jager 2006).

Research that considers the influence of the broader socio-technical system on the behavioural responses to solar PV has been conducted by Keirstead (2007). He used solar PV households in the UK as a case to investigate whether the use of solar PV could have a double effect, providing renewable energy as well as inducing certain changes in the use of energy. His research showed that the installation of solar PV encouraged households to reduce their overall electricity consumption by approximately 6% and shifted demand to times of peak generation (Keirstead 2007). Palm and Tengvard (2011) also studied the adoption of solar PV from a broader socio-technical perspective and embedded their work within the transition literature. Analysis of material from in-depth interviews with members of twenty Swedish households revealed that environmental concerns are the main motive for adopting solar PV systems or micro-wind turbines. Other reported motives were ecologically aware lifestyles, symbolic investments (providing a way to display environmental consciousness) a protest against "the system", with its large dominant companies, or a step toward self-sufficiency. Some households rejected these installations because of financial considerations, respect for neighbours who might object, and/or difficulties finding an appropriate site (Palm and Tengvard 2011).

8.3 The adoption and diffusion of solar PV in the Netherlands

A glimpse of the past

Although the first off-grid solar house was opened in the town of Castricum in 1988 (Lysen 2006), the use of solar PV remains rather limited more than 25 years later. The slow growth and even decline in the Netherlands over the years contrasts sharply with the explosive growth in other European countries, Germany for example, where incentive schemes have stimulated the growth of installed PV capacity to such an extent that up to 7 GW is now being produced per year (IEA-PVPS 2014). The Dutch case clearly shows that a major problem in the formation of a domestic market lies in inconsistent government market support. For example, the upward trend of installed PV stalled in 2003, the solar PV market decreased from almost 20 MW per year in 2003 to less than 0.5 MW per year in 2006. The "gold rush of 2003" was the result of a governmental announcement that a subsidy regime would end. No incentive replaced it until 2008, and the new incentive did not have a significant impact on the market. The Dutch policy focused on research and development, with the goal of bringing costs down and raising the efficiency to make solar power more competitive with fossil fuels (Vasseur and Kemp 2011).

Interestingly, there has been a substantial growth since 2011, with 195 MW PV capacity installed over 2012. Falling prices and the possibility of net metering make it more interesting for individuals to install panels without subsidy (IEA-PVPS 2013). This works well with the frontrunners, but it is probably not enough to motivate the majority of citizens, unless there is a win-win situation.

How to get a majority of the citizens involved?

This question is used as a starting point and we assume that the answer is simple: the PV supply side must be more strategic. Rather than develop PV projects based on what "they" think will be attractive to users, they need to test their assumptions among the intended public to fully understand what they want and need and why. Understanding their needs to make adoption easier, more meaningful, and more significant is a prerequisite. Through intensive research, questionnaires, observation, and interviews with (potential) users, we tried to find out what users wanted almost before they were even able to fully express it. In order to classify the respondents, we used a segmentation model which was introduced for the purpose of analysing the diffusion of technological innovations, in particular solar PV (Vasseur and Kemp 2015)[8]. The model

[8] The attitude of PV adopters and individual preferences (adoption or not) were assessed by means of different questions. First we asked whether the respondents owned a PV system. If they did, we asked who had decided on the purchase of the system. If the respondent had decided the purchase by themselves, we labelled this respondent as having a positive attitude, if not, we labelled them as having a neutral or negative

allowed us to answer the question whether adopters and non-adopters consider the same or different attributes in their decisions. The four groups were voluntary adopters, involuntary adopters (people who bought a house equipped with solar PV), potential adopters, and rejecters.

What we found is that adopters consider the costs of adoption affordable, whereas non-adopters view them as too high. The differences have to do with adopters valuing the benefits of this technology more than non-adopters, so they included this determining factor as a benefit of having solar PV, obviously referring to the positive consequences of having a system (e.g. self-sufficiency and environmental benefits). For non-adopters, the benefits of solar PV, which also refer to the positive consequences of having a system, do not outweigh the negative consequences (e.g. costs and financial uncertainty). Whether they adopt PV panels or not is not a matter of costs only, although they certainly are an important element. Unless electricity prices rise significantly and the costs of PV systems decrease substantially, we expect the diffusion of PV systems to remain slow.

Furthermore, we found that one of the reasons why potential adopters had not adopted a system so far is that they lacked knowledge about solar PV. The importance of this emerged from the statistical analysis, where we found that knowledge about solar PV was a predictor of adoption. (The influence of this variable was only revealed by the statistical analysis; the lack of knowledge was not stated by the respondents as a reason for non-adoption.) This suggests that more information about solar energy will stimulate adoption. It is not only information on the costs and quality aspects that is important, but also information on social and environmental matters. The importance of the latter and knowledge about grants and costs were found to be positive predictors of the willingness to adopt. This suggests two useful strategies to stimulate the diffusion of solar PV: reducing the investment costs and increasing the public's knowledge about it. The relative effectiveness of these two strategies cannot be determined from our analysis.

The most important motives to adopt PV are saving electricity costs, the costs of a PV system and the possibility to be self-sufficient. The fact that with the use of a PV system one has less environmental impact has also been an important reason for people to adopt. The innovativeness of a system, the visual aspects and the ease with which a system can be installed were less important motives for our respondents to adopt a system. These results are not in line with the research by Jager (2006) and Palm and Tengvard (2011), who rated the contribution to a better natural environment as the most important motive for adoption. Palm and Tengvard (2011) also indicated the symbolic meaning as an important aspect, which is also not in line with our findings.

---

attitude. If they did not own a PV system, a distinction was made between respondents who were willing to purchase a system (indicating that they were in the orientation phase or that they would consider the purchase when more people decided to opt for a system) or not; labelling them as non-adopters with a positive attitude and non-adopters with a negative/neutral attitude, respectively.

As regards the non-determining factors, voluntary adopters were on average middle-aged, highly educated, likely to take major decisions without being influenced by the opinions of others and likely to want to protect the environment, for example by recycling paper and avoiding frequent car use. By contrast, the rejecters had a lower average income, tended to take major decisions after considering other people's opinions, and needed considerable time to take major decisions.

8.4 Conclusion and outlook

We found that the slow adoption and diffusion of solar PV is not driven by single factors such as price or technology change, but typically involves co-evolution between multiple developments. It is related to consumer preferences, product offerings and slow introduction of policies to promote the use of renewables. Knowledgeability has a positive influence on future adoption, confirming the empirical findings of Labay and Kinnear (1981) on the role of knowledge. This suggests that informing the public about the possibilities and procedures may be effective in persuading those interested in adopting solar PV (potential adopters). Similar findings have been reported by Kaplan (1999) and Jager (2006). Many initiatives are emerging to encourage these informative activities, at local and regional levels. These initiatives can provide potential adopters with the necessary information regarding solar energy, in order to reduce perceived complexities, but they can also facilitate the collective procurement of solar PV systems so as to benefit from economies of scale. Most of these initiatives are not connected to the policy process, but are indirectly influenced by the broader debate on the sustainability transition. We argue that these local and regional activities are starting to set the pace and direction of this transition.

In view of this conclusion, it is relevant to ask what is the next step in encouraging the adoption and diffusion of solar PV? We have made a first attempt to include the users of the technology and view them as an important source of information, but we have not yet made an attempt to study the feedback from users that producers have obtained over time. This remains a topic for further research.

References

Cesta, J.R. and P.G. Decker (1978). Speeding solar energy commercialization: A Delphi research of marketplace factors. *Journal of Business Research*, 6(4), pp.311-328.

Faiers, A. and C. Neame (2006). Consumer attitudes towards domestic solar power systems. *Energy Policy*, 34(14), pp.1797-1806.

Gostelie, E., J. Maas, et al. (2010). *Groen licht voor groene stroom*. Amsterdam, Boston Consulting Group.

IEA-PVPS (2013). *National Survey Report of PV Power Applications in the Netherlands 2012*.

IEA-PVPS (2014). *Annual report 2013 - Implementing Agreement on Photovoltaic Power Systems*.

Jager, W. (2006). Stimulating the diffusion of photovoltaic systems: A behavioural perspective. *Energy Policy*, 34, pp.1935-1943.

Kaplan, A.W. (1999). From passive to active about solar electricity: innovation decision process and photovoltaic interest generation. *Technovation*, 19(8), pp.467-481.

Keirstead, J. (2007). Behavioural responses to photovoltaic systems in the UK domestic sector. *Energy Policy*, 35, pp.4128-4141.

Labay, D.G. and T.C. Kinnear (1981). Exploring the consumer decision process in the adoption of solar energy systems. *Journal of Consumer Research*, 8(3), pp.271-278.

Lysen, E. (2006). *Fifty years of solar PV in the Netherlands*. Utrecht Centre for Energy research.

Palm, J. and M. Tengvard (2011). Motives for and barriers to household adoption of small-scale production of electricity: examples from Sweden. *Sustainability: Science, Practice, & Policy*, 7(1), pp.6-15.

Rogers, E. (1995). *Diffusion of Innovations*. New York, Free Press (Original work published 1964).

Vasseur, V. and R. Kemp (2011). The role of policy in the evolution of technological innovation systems for photovoltaic power in Germany and the Netherlands. *International Journal of Technology, Policy and Management*, 11(3/4), pp.307-327.

Vasseur, V. and R. Kemp (2015). A segmentation analysis: The case of photovoltaic in the Netherlands. *Energy Efficiency*, 8 (6), pp.1105-1123.