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Stimulating the diffusion of photovoltaic systems: A behavioural perspective

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Abstract

This paper first discusses consumer motives for adopting photovoltaic systems (PV systems) from a behavioural-theoretical perspective. Different motives are discussed within a framework of underlying needs and the time sensitivity of various outcomes. Next, empirical data are presented concerning the motives of buyers of PV systems after a promotional and support campaign in the city of Groningen (the Netherlands). Financial support and general problem awareness are found to be critical motives, but the (strong) positive effects of information meetings, technical support meetings and social networks are also identified. Conclusions focus on the critical motives for adopting a PV system, and suggestions are presented concerning policy measures to stimulate the further diffusion of PV systems.

Keywords: Solar power; Behaviour; Motives

1. Introduction

In recent years, attention to strategies to reduce the consumption of energy produced from fossil fuels has increased. The Kyoto agreement provides targets for many countries for the decrease of fossil fuel consumption aimed at lowering CO_2 emissions. Individual consumers installing photovoltaic systems (PV systems) connected to the power grid are one strategy for the reduction of such emissions. As PV systems are still quite expensive, the financial break-even period for PV systems roughly matches their life expectancy, about 30 years. Rising energy prices would shorten this break-even period, but given the privatisation of the Dutch energy market, this rise is not to be expected in the near future. Therefore, the Dutch government decided to subsidise PV systems to a large extent. Originally, larger projects aimed at research and development were subsidised; however, in 2001 smaller PV systems were also subsidised by the Energie Premie Regeling—energy subsidy scheme (EPR). This allowed individual consumers to receive a grant for the installation of a PV system. A question that arises at this point is whether subsidising PV systems benefits the diffusion of this technology. An increase in the total kWp installed (Fig. 1) can be discerned when considering the private ownership of PV systems. Fig. 1 suggests that the diffusion of PV systems is picking up pace.

The media declared the diffusion of PV systems in 2003 to be a success as the amount of grants requested (€175 million) far exceeded the available EPR subsidy budget (€76 million), causing some financial turmoil in Dutch policy. As a consequence of the unanticipated large number of requests, the Dutch government decided to terminate the EPR subsidy in 2004, since when hardly any PV systems have been sold. The EPR subsidies were granted for several kinds of domestic energy-saving measures, such as low-energy refrigerators, washing machines, high-efficiency heating systems and all kinds of insulation measures. An estimated total of €13 million was granted in 2002 for the installation of 1240 kWp PV solar energy systems on new and existing buildings (Van Beek et al., 2003, p. 20). Although the

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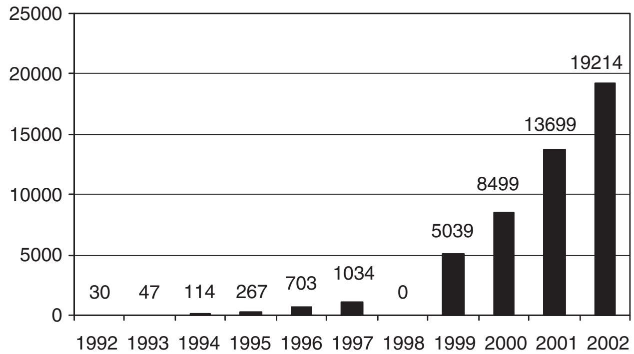

Fig. 1. kWp installed in privately owned PV installations connected to the power grid in the Netherlands (no data for the year 1998).

media interpreted these figures as indicating success, from a strictly financial-economic perspective we could argue that the diffusion of PV was lower than expected. Considering that grants covered about 90% of the costs of a PV system, the resulting break-even period of about 3 yr should have been economically appealing for a much larger proportion of Dutch home owners — 3,592,000 in 2002 (CBS, 2003). Even in view of the fact that many of these homes are not suitable for the installation of PV systems, for example due to their construction or orientation towards the sun, mounting a PV system ought to have been very attractive financially for many homeowners. Hence, contrary to the media, we consider the effect of the grants to have been modest. We expect grants to function as a necessary but insufficient condition for the adoption of PV systems. In this study, we wanted to explore other motives than financial that owners of PV systems had when purchasing a PV system. Obviously, financial motives are expected to be important but aspects like environmental problem awareness and technical and bureaucratic barriers may have also had a significant influence on the decision to purchase a PV system. Studying the purchase motives of adopters may disclose to what extent these additional factors affected the purchase behaviour of different groups of PV adopters. This may contribute to the development of effective strategies in stimulating the diffusion of PV systems.

In Groningen, the Netherlands, special information and instruction meetings on PV systems were organised, and these meetings specifically addressed motives related to technical and bureaucratic barriers. This setting enabled the study of how these meetings affected buyer motives. Additionally, comparing PV systems sales in Groningen with sales in the rest of the Netherlands facilitated the measurement of the effectiveness of addressing these motives, since in the rest of the Netherlands the same subsidy regime was applied, only without the special meetings. As a result, whether removing technical and financial barriers actually affects purchasing behaviour can be tested. Before focussing on empirical data, a behavioural perspective of the motives behind the purchase of PV systems that exceeds the financial-economic perspective will be described.

2. A behavioural perspective on the purchase of a PV system

Buying a PV system is a high-involvement decision people usually make once in their lives. Typical for high involvement decisions is that people are willing to invest cognitive effort in the decision-making process. Whereas people use simple strategies (heuristics) when the outcomes of a decision are less important (e.g., Tversky, 1972), planned behaviour (or central processing) is a more prevalent strategy when the decision at hand is more important. For example, the Elaboration Likelihood Model of Petty and Cacioppo (1986) states that people are more inclined to process arguments when highly motivated. In terms of the Theory of Planned Behaviour (e.g., Ajzen, 1991), people will evaluate the outcomes of behaviour in terms of its importance. This importance can be related to the extent behaviour affects the satisfaction of a person's needs. The more a person's needs are affected by the decision, the more important the decision is and the more cognitive effort is likely to be invested in the process (e.g., Jager and Janssen, 2003).

Because people have different needs (e.g., McDougall, 1928; Maslow, 1954; Max-Neef, 1992), the consequences of a decision may have an impact on several needs simultaneously. The decision to install a PV system on the roof of a house may thus touch upon the satisfaction of various needs. Although there are many typologies of needs (see e.g., Jackson et al., 2004), an empirically grounded taxonomy has been proposed by Max-Neef (1992), who distinguishes between subsistence, protection, affection, understanding, participation, leisure, creation, identity and freedom as drivers of behaviour. An individual behaviour, like the purchase of a PV system, may affect different needs simultaneously. The needs involved in this decision may relate to subsistence (very abstract, relating to environmental conditions of mankind in the long term), belongingness (if friends or neighbours also have this kind of system), participation (collaborating with other people in installing a PV system), creation (home improvement, though the appearance of a PV system can also be disliked), identity (being an environmentally sensitive person) and freedom (achieving relative independence from power companies). Moreover, the money potentially saved by using a PV system can be spent on other consumer behaviours satisfying other needs.

Some needs have more of a bearing on an individual's character, such as subsistence and identity, whereas other needs are more socially oriented, such as belongingness and participation. It has often been reported in diffusion processes in particular that innovators and early adopters assign more relative weight to individual needs than later adopters (the majority), who assign more weight to social needs (e.g., Rogers, 1995). Network effects may be critical in the diffusion process, as not only information on the innovation is communicated through social networks, but also social norms related to social needs (e.g., Delre et al., 2004). Within the context of home insulation measurements, Weenig and Midden (1991) report that information diffusion and final adoption were related to the social ties people had, thus signifying the importance of network effects.

The speed and degree to which an innovation diffuses is related to several factors. Rogers (1995, p. 206) states that most of the variance (49% to 87%) in the rate of adoption is explained by five attributes of the innovation: (1) relative advantage, (2) compatibility, (3) complexity, (4), trialability, and (5) observability. While it may be obvious to a consumer at a superficial level that a PV system provides a relative advantage in generating clean electricity and is compatible with the existing electrical installation, the operational choice presents a very complex situation. Different providers offer various systems, varying with respect to size, price and returns. Moreover, as it is not possible to trial a system for a limited period before purchase, the final choice has to be made without the opportunity to test the system. This lack of trialability is also confirmed by Labay and Kinnear (1981), who report that adopters do not experience a higher trialability of solar energy systems than non-adopters. Therefore, information has to be collected on the purchaser's home's suitability for mounting different systems, which involves an analysis of the construction. Moreover, whether the existing electrical installation allows for the connection of a PV system has to be evaluated, and whether the electricity meter registers occasional surpluses of electricity being delivered to the power company. This requires a level of knowledge most consumers do not possess, and which is hard to acquire in the short term. In terms of the Fishbein and Ajzen (1975) model of reasoned action, this lack of technical expertise constitutes a barrier reducing a person's control over the behaviour. Often, consultation of an expert (e.g. construction firm) is required to overcome this barrier. In addition, in many situations, the approval of the municipal planning and construction authorities are required for the mounting of a PV system, which involves an administrative procedure, thus constituting a bureaucratic barrier. The financial consequences are also complex. Firstly, the direct price of a PV system is quite high considering the returns. A single PV panel of about 120 kWh/yr is available for about €1250 and saves about €40 a year, breaking even in 30 years, provided that energy prices remain at their current levels. This break-even point depends on the price the energy company pays for the surplus energy delivered to the network. The estimated lifetime of this kind of system is about 30 years. Obviously, in promoting the installation of PV systems, governments and lower-level institutions offered support grants to shorten the break-even point, making the installation of PV systems financially more attractive. For example, in 2003 in the Netherlands, a number of subsidy arrangements were available at state, provincial and municipal levels that amounted to about €1100 per panel, decreasing the break-even point to about 2.5 years. However, applying for these grants required considerable administrative skill and effort.

Obviously, mainly people who (1) are highly involved because they perceive a PV system as important in satisfying some of their aforementioned needs, and (2) have sufficient time, cognitive capacity and knowledge will overcome the complexities of this decision problem and consider buying a PV system. However, due to the complexity of the decision, people are unlikely to have all the required information to hand immediately, and the decision process may take considerable time and effort. In the early stages people will have far from complete information and will experience negative short term outcomes in terms of financial investment, administrative procedures and construction work, while the positive outcomes are more abstract and partly become manifest in the long term.

The effects of the temporal distance of outcomes on intertemporal choice have been extensively studied (see e.g., Loewenstein and Elster, 1992; Roelofsma, 1996; Chapman, 1998). Basically, people tend to devalue or discount delayed outcomes. As a consequence, people want to obtain positive outcomes sooner rather than later, while preferring to postpone negative consequences. The purchase of a PV system typically yields negative outcomes at the time of purchase, while positive outcomes are delayed. This causes a dilemma situation, involving a conflict between direct and delayed outcomes that can provoke cognitive dissonance reactions. Here, people are tempted to discount the long-term positive outcomes by employing arguments like 'too expensive', 'too much paperwork', 'it hardly contributes to the environment' or 'cannot oversee the construction process'. As a consequence, initially interested consumers may decide not to invest in a PV system.

Reducing the complexity of the decision and the time discounting framing of the decision-problem would stimulate consumers to install a PV system. Expert support at the decision-making stage would reduce the complexity consumers experience. People already in possession of a PV system may function as advisors with respect to the installation of a PV system and the administrative procedures involved. This relates to the observability of the innovation as mentioned by Rogers (1995). When a consumer has a direct contact with, for example, a neighbour or friend who has successfully installed a PV system, social comparison processes may facilitate the exchange of information, both on the satisfaction they derive from owning a PV system and on the technical and administrative procedures. This would reduce the complexity of the decision-making context and make the situation more favourable for adoption. Especially in such complex decision situations, network effects may play a crucial role in people's decisions to adopt. The more people in a social network who have already adopted a PV system, the more information will be available. Moreover, the member's adoption into a network may also increase the involvement of people initially not interested or aware of the possibility to install a PV system. The more people who adopt a PV system, the more strongly will this observability effect stimulate further diffusion. However, where few people have a PV system, observability might be low, which may explain why Labay and Kinnear (1981) did not find a difference between reported observability of solar energy systems between adopters and non-adopters.

The focus in an empirical study is on the motives people had for buying a PV system, concentrating on individual and social (network related) needs. In the late 2002, the municipality of Groningen announced an initiative to stimulate citizens to buy a PV system. Three successive half-page ads were published in the local newspaper informing citizens about the PV initiative and the information meeting, where more details were presented concerning the type of systems involved, the costs, the available grants, and the central organisation of the grant applications that would reduce the bureaucratic paperwork for buyers. These information meetings clarified the level of subsidy, and made it easier to determine the pay-off time for buying a PV system. As the grants amounted to about €1100 per panel, the break-even point decreased to about 2.5 years, thus seriously decreasing the financial temporal dilemma. Following the general information meeting, a series of smaller-scale instruction evenings were organised in various neighbourhoods where the technicalities of mounting a PV system were explained and demonstrated. Of a total population of about 175,000 people, 175 people visited the first information meeting, 280 people adopted a PV system, and a total of 1155 panels were sold.

To estimate the success of this approach, we compared the average subsidy amount as granted in Groningen with the average for the Netherlands. Since Groningen is a university city with many rented houses, we decided to divide the total subsidy as granted in Groningen by the number of owner-occupiers. Only a small proportion (less than 10%) of our sample actually rented a house. In the municipality of Groningen there were 31,376 owner-occupiers (Statistisch Jaarboek Gemeente Groningen), who on average received €40.48 (€1.27million (€1100 for 1155 panels) divided by 31,376). In the Netherlands as a whole there are 3,619,000 owner-occupiers (CBS, 2003). Dividing the total €13,027,719 across these 3,619,000 owner-occupiers results in €3.60, considerably lower than the Groningen average subsidy granted. Assuming that a small proportion of our sample actually rented a house, it can be concluded that the large investments of the municipality of Groningen in promoting PV systems resulted in an adoption rate of about 10 times the Dutch average as calculated.

Using a survey, we studied how the adopters were informed about this initiative, their motives for buying a PV system, the perceived barriers, the social network effects that played a role, and to what extent the information and instruction meetings affected their motives.

3. Method

A questionnaire was developed aimed at measuring (1) demographic characteristics, (2) general environmental problem awareness (12 questions from the old NEP scale: Dunlap, Van Liere, 1978; Dunlap et al., 2000), the visiting and evaluation of the information evening (12 questions), the visiting and evaluation of the instruction evening (six questions), motives for purchasing a PV system (nine questions) and the installation of the PV system (three questions). This questionnaire was sent in April 2004, about a year after the PV initiative.

Following that, a dataset containing the scores of 108 representative inhabitants of Groningen on the (new) NEP scale was produced. These data were obtained in 2003 in a project where people were approached in the street (Dreyerink, 2003).

4. Results

4.1. Sample

Questionnaires were sent to all 279[1] people who bought a PV system. A total of 197 respondents returned the questionnaires, resulting in a response rate of 71%. This high response rate indicates that the buyers were highly involved. Of the respondents, 149 (75.6%) were male, and 46 (23.4%) female. The average age of the respondents was 46.74 years, with a standard

[1]As the author of the paper also adopted a PV system, he has been omitted from the sample.

deviation of 9.82. Concerning their income, 37 (18.8%) had an income below €20,000, 86 (43.7%) had an income between €20,000 and €40,000, and 68 (34.5%) had an income of over €40,000. Concerning education, 10 respondents (5.1%) had a secondary school diploma, 24 (12.2%) were MBO graduates (from a vocational school), 84 (42.6%) were HBO graduates (comparable to having a Bachelor's degree) and 77 (39.1%) had a WO degree (comparable to a Master's degree). These results are partly in line with the results of Labay and Kinnear (1981). They also found that adopters of solar energy systems have a higher education and a higher income than the average population. However, their observation that adopters are younger is not confirmed in this research. In conclusion, the sample consist mainly of middle-aged men of relatively high income and educational levels, which is in line with Rogers'(1995) description of this group as successful people of a high status.

4.2. Problem awareness

To test whether the generic problem awareness of the buyers of PV systems was higher than average, we asked them to indicate their agreement with a number of statements using a 5-point Likert-scale. The 108 randomly selected inhabitants of Groningen also rated these items. Because the old and the new NEP scales differ, and the random sample data were based on the new NEP scale whereas our sample was based on the old NEP scale, we decided to include only the seven statements of the NEP scale that were used in both the old and the new NEP scale in this test. These statements were: (1) humanity was created to rule over nature, (2) people have the right to change their natural environment in order to satisfy their needs, (3) we have almost reached the limits of the number of people the Earth can support, (4) the balance of nature is very sensitive and can be disturbed easily, (5) when people interfere with nature this often results in disaster, (6) Earth is like a spaceship with limited space and means, and (7) humanity is seriously abusing the natural environment. To test whether these seven statements could be used to construct a scale we performed a reliability analysis. The alpha value of the scale was .60 for the random sample and .58 for the buyers. This indicates reasonable scale reliability.

Next, the variable problem awareness was constructed by summing the scores on these seven statements (recoding items 1 and 2) and dividing the total score by 7. The scores ranged from 1 (very low problem awareness) to 5 (very high problem awareness). Testing showed that the distribution of problem awareness met the normality criterion. The average score of the buyers was tested against the scores of a representative sample of 108 inhabitants of Groningen. The data of this group also met the normality criterion. A T-test revealed that the buyers of a PV system had on average a higher problem awareness (score = 3.70) than average people (score = 3.05) ($T = -12.19$, df = 285,087, $p < .001$).

4.3. Motives for purchasing a PV system

We asked the respondents to rate several aspects in deciding to adopt a PV system by importance. Scores ranged from 1 (unimportant) to 5 (very important). In Table 1 the importance of the aspects are ranked from important (top) to unimportant (bottom).

In an additional analysis, the motives of buyers with different problem awarenesses were compared. Problem awareness was measured by summing the scores on the seven items of the NEP scale and dividing the result by 7. The resulting scores on problem awareness ranged from to 2.43 to 5.00. Two roughly equally sized groups were created by setting the cut-off point at 3.71 (26/7). This resulted in one group ($n = 99$) with a relatively high problem awareness (equal to or greater than 3.71, avg. 4.11), and one group ($n = 87$) with a relatively low problem awareness (below 3.71, avg. 3.26). Note that the relatively low problem awareness group still has a higher average problem awareness than that observed in the random sample (3.05). The nine motives all displayed a close to normal distribution. A T-test was performed on the average scores on the nine motives as discussed above. The results revealed that the grant offered was relatively less important for the high involvement group (avg. 4.05) than for the low involvement group (4.39) ($T = -2.48$, df = 186, $p < .05$). Consequently, it was found that independence from the electricity supplier was relatively more important for the high involvement group (avg. 2.65) than for the low involvement group (avg. 2.30) ($T = 1.97$, df = 185, $p < .05$). Finally, though not significantly, discussion with other owners appeared to be a more important motive for the low involvement

Table 1
Importance of aspects in purchasing a PV system (ranked from important to unimportant)

Aspects being rated	Average score
The contribution to a better natural environment	4.22
The grant on offer	4.21
The increased value of my home	2.97
The central organisation of the request for a grant	2.79
Independence from electricity supplier	2.49
Discussion with other owners convinced me to adopt	2.32
The decorative value for my home	2.28
The buying of PV systems by neighbours/ acquaintances	2.07
The technical support offered by the municipality	1.89

group (avg 2.46) than for the high involvement group (avg. 2.12) ($T = -191$, df = 183, $p = .057$).

In conclusion, environmental benefits and grants were the most important motives for adoption. People with lower problem awareness appeared to find the financial and social motives more relevant, while the high involvement group found independence from the electricity supplier a more important motive.

4.4. Installation of a PV system

Of the respondents in our sample, 132 installed the system themselves. The 63 respondents that received assistance in mounting the system hired a professional (46), installed it with the help of family or friends (22), were assisted by other owners of a PV system (15) or a neighbour (six). A total of 50 respondents assisted other people in installing their PV systems. Obviously this mainly relates to adopters outside the sample of respondents.

4.5. Information and instruction meeting

Of the 188 respondents that answered the question on the meetings, a total of 97 reported having visited the information meeting, and 86 reported having visited the instruction evening. Table 2 shows how many people visited both, either one of the two or neither.

Table 2 shows that a majority of respondents either visited both meetings or neither. The four groups did not significantly differ with respect to general problem awareness.

Of the respondents, 148 out of 196 (75%) were aware of the information evening. The respondents reported having been informed about this information meeting by newspaper ads (126 of 189, 64%), acquaintances (49 of 189, 24.9%), or a neighbour (six of 189, 3.0%). Concerning the instruction evening, 128 out of 191 (65.0%) were aware of the instruction evening. The respondents reported having been informed about this instruction meeting by newspaper ads (64 of 177, 32.5%), acquaintances (60 of 179, 60.4%), or a neighbour (19 of 176, 9.6%). It is remarkable that 32.2% of the respondents reported having been informed about the instruction evening by means of newspaper ads because the ads were only published for the information evening. This indicates that many people were not capable of recalling the precise contents of these advertisements.

Table 2
Crosstabs for the numbers of respondents visiting the information and instruction meetings

	Visited instruction meeting	Did not visit instruction meeting	Total
Visited information meeting	70	27	97
Did not visited information meeting	16	75	91
Total	86	102	188

We conclude that the newspaper ads played an important role in informing the respondents. Acquaintances also appear to have played a relevant role in spreading information on the meetings.

4.6. Effects of the information meetings

One hundred participants (50.8%) visited the information meeting. Of these participants, 85 (85%) reported having read the newspaper announcement of this meeting and 23 (23%) reported having been informed by other people. Before the meeting, seven people (7%) were not aware of the fact that the state provided grants, 18 (18%) were not aware of the grants at a county level and 17 (17%) were not aware of grants at the municipality level. Finally, 66 (66%) of the respondents did not know in advance that a single party would co-ordinate the submission of all applications for grants, thus facilitating the paperwork.

We asked whether people perceived the technical installation of the PV system as a barrier to adopting a PV system, before and after the information meeting. Both variables displayed a close to normal distribution. On average, the technical installation was not perceived as a serious barrier before the meeting (average score of 2.27 on a 5-point scale), and even less so after the meeting (avg. 1.83) ($T = 5.09$, df = 106, $p < .001$). Moreover, the perception of the difficulty of submitting a request for a grant (bureaucratic barrier) decreased from 2.33 to 1.92 ($T = 4.92$, df = 105, $p < .001$).

A further analysis studied whether people experiencing a decrease in the perceived barrier also changed their motives after the information meeting. Sixty-five people were observed not to have changed their perceptions, against 33 who stated that their perceptions of the technical barrier had reduced. These two groups were compared with respect to the nine motives for purchasing a PV system. A T-test revealed that the group with the reduced barrier indicated the technical support offered by the municipality as a more important motive (avg. 2.48) than the group without a reduced barrier (avg. 1.91) ($T = 2.73$, df = 96, $p < .01$). The reduced barrier group also indicated that they were more motivated by the central organisation of the request for a grant (avg. 3.06) than the group without a reduced barrier (avg. 2.60) ($T = 1.96$, df = 78.901, $p = .052$, ns).

A subsequent analysis tested whether people differing on problem awareness also differed with respect to the effect of the information meeting on their perception of barriers. No such effects were found.

We conclude that the information meeting succeeded in informing people about the grants, in informing most of the people about the procedure for submitting a request for a grant and reduced their perception of the technical installation as being a barrier to adoption. A subset of people actually changed their perception of barriers. Moreover, the subset of people who indicated that their perception of technological barriers had reduced also indicated that they had been more motivated to purchase a PV system because of the technical support offered and the central organisation of the grant request.

4.7. Effects of the instruction meeting

Eighty-six participants visited the instruction evening. Most people visited this instruction meeting alone (59, 68.6%), 21 (24.4%) were accompanied by a neighbour, and seven (8.1%) came with a family member.

They were asked whether they perceived the technical installation of the PV system as a barrier for adopting a PV system before and after the instruction meeting. On average, people perceived technical installation as not much of a barrier before the meeting (average score of 2.33 on a 5-point scale), and even less so after the meeting (avg. 1.89) ($T = 5.37$, $\mathrm{df} = 93$, $p < .001$).

Furthermore, an additional analysis studied whether people who experienced a decrease in the perceived barrier also changed their seven motives after attending the instruction meeting. We observed 46 people who did not change their perception, against 27 who stated that their perception of the technical barrier had reduced. These two groups were compared with respect to the nine motives for purchasing a PV system. A T-test revealed that the group with the reduced barrier indicated the technical support offered by the municipality as a more important motive (avg. 2.59) than the group without a reduced barrier (avg. 2.11) ($T = 2.06$, $\mathrm{df} = 71$, $p < .05$).

Finally, whether people differing on problem awareness also differed with respect to the effect of the instruction meeting on their perception of barriers was tested. No such effect was found.

We conclude that although most people did not perceive the technical installation as a serious barrier, the instruction evening contributed to the further decrease of this barrier. Those reporting a decrease in this barrier also found that the technological support was a more important motive to adopt.

4.8. Social support and contacts

People who indicated knowing relatively few other people owning PV systems (<3, average 1.2, $n = 77$) were compared with people who indicated knowing more people owning PV systems ($> = 3$, average 7.00, $n = 99$). Whether these groups differed with respect to the seven motives for purchasing a PV system was tested. It was discovered that people knowing more owners of PV systems stated that the purchase of PV systems by neighbours/acquaintances was a more important motive (avg. 2.28) than people who knew fewer owners of PV systems (avg. 1.87) ($T = 2.39$, $\mathrm{df} = 172{,}179$, $p < .05$).

It was also found that people knowing more owners of PV systems stated that 'discussion with other owners convinced me to adopt' more often as a motive for adoption (avg. 2.59) than people knowing fewer owners of PV systems (avg. 2.01) ($T = 3.26$, $\mathrm{df} = 169{,}639$, $p < .005$).

Subsequently, whether people knowing more owners responded differently to the information and instruction meetings was tested. It was found that people knowing more PV system owners reported a larger decrease (avg. 0.54) in their perception of the difficulty of submitting an application (the bureaucratic barrier) for a grant than people knowing fewer PV system owners (avg. 0.17) ($T = 2.37$, $\mathrm{df} = 74.787$, $p < .05$). People knowing more against fewer PV system owners did not differ in their perception of the barriers before the meetings.

It was then tested whether the seven motives for purchasing a PV system differed for the respondents who were informed about the information evening by their acquaintances (socially informed) in comparison to the respondents who reported not to have been informed by acquaintances (not socially informed). We found that the socially informed group reported the purchase of PV systems by neighbours/acquaintances to have been a more important motive (avg. 2.53) than the not socially informed group (avg. 1.87) ($T = 3.35$, $\mathrm{df} = 72.081$, $p < .01$). This indicates that social norms and underlying social needs play a more important role in the decision-making process of the socially informed group. The motive to contribute to a better natural environment appeared to be less important for the socially informed group (avg. 4.00) than for the socially uninformed group (avg. 4.31) ($T = -2.38$, $\mathrm{df} = 186$, $p < .05$).

Despite the socially informed group demonstrating slightly lower problem awareness than those not socially informed, no significant difference was found.

We conclude that although the social motives for adopting a PV system are not strong, the more other PV owners a person knows, the stronger these social motives become. Moreover, the more PV owners a person knows, the more effective the information meeting was in decreasing the perceived bureaucratic barrier. People who were socially informed attached greater importance to the social motives for purchasing a PV system, and less value to environmental motives.

5. Discussion

Basically, our results demonstrate that the information and support meetings as organised in Groningen had a strong positive effect on the diffusion of PV systems, probably due to the reduction of perceived technical and bureaucratic barriers. In terms of the factors affecting the speed and degree of diffusion (e.g. Rogers, 1995), these meetings reduced the complexity of the decision problem as experienced by the buyers. Moreover, the results reveal that the buyers of PV systems had higher general environmental problem awareness than average citizens of Groningen, suggesting that they were more aware of the relative advantages of PV systems. Greater problem awareness indicates that needs related to environmental protection, for example long-term subsistence and identity as an environmentally sensitive person, play a more important role in the perception of the decision problem. This would stimulate people to invest more cognitive effort in the decision-making process. This suggests problem awareness functions as a prerequisite—only those interested in the topic will be motivated to read more about the action. Possible cognitive dissonance effects can subsequently be counteracted by means of specific support in bureaucratic and technical barriers. Therefore, although public information on environmental problems, particularly related to the use of energy, can be important, it is insufficient to stimulate the diffusion of PV systems. Most interestingly, buyers who were informed of the initiative by their social contacts had somewhat lower problem awareness. Despite the fact that their problem awareness was still on the high side, this suggests that people with lower general problem awareness were less triggered by the newspaper ads, indicating that they invested less cognitive effort in the initial phase of their decision-making process. Owing to contacts in their social network, they were nonetheless informed about the action.

Another interesting result was that people who knew more owners of PV systems perceived the bureaucratic procedures as less of a barrier after the meetings, whereas people who knew fewer PV system owners did not change their perceptions. It is reasonable to assume that the group who knew more PV owners had a greater chance of hearing of negative experiences from other PV system owners. This might have resulted in the perceived bureaucratic barrier being more serious, which might have been counteracted by the meetings, thus explaining this result. However, testing revealed no difference between the barriers as perceived before the meeting. This suggests that they did not hear negative experiences from other owners concerning the bureaucratic barrier.

Besides the propagation of information, social networks also form the vehicle by which social norms are communicated. In PV systems, social norms relate to social needs such as belongingness and participation. Our results indicate that social motives are more important to people investing less cognitive effort in the initial phase of the decision process. These results are in line with Rogers (1995), who reports that innovators and early adopters accord relatively little value to social outcomes, whereas later adopters accord relatively more value to these social outcomes. Since the people with relatively low problem awareness in our sample still displayed higher problem awareness than the average population (random sample), this social need might be expected to be even more important in the decision-making process of the general population. This signifies the importance of social network effects in the further diffusion of PV systems. Therefore, we expect people adopting a PV system to serve as nodes in their social networks, thus playing an important role in the further diffusion of PV systems through the population. These results suggest that viral marketing, where a selected group of well-connected and influential people is stimulated to adopt a PV system, may provide an effective strategy for stimulating the further diffusion of PV systems through network effects. The more people adopting, the greater the observability of PV systems, which will also contribute to the further diffusion of PV systems.

As the financial cost of buying a PV system is a very important determinant, the termination of the grants in the Netherlands is likely to stop the relatively rapid diffusion of PV systems under private homeowners. It is not expected that these grants will return in the near future. Unless electricity prices rise significantly and the costs of PV systems decrease substantially, we expect the diffusion of PV systems to decelerate. Therefore, other policy strategies should be developed to solve the financial time dilemma of installing a PV system. Basically, the solution resides in paying the costs of a PV system over a number of years, preferably in such a way that the financial investments and revenues of the PV system balance each other out. By spreading the large investment costs over a number of years, the financial barrier to investment can be eliminated, thus solving the temporal dilemma. An initial possibility to realise this would be to include the costs of such a system in the mortgage. Particularly when consumers buy new houses, they make long-term calculations concerning the mortgage and their financial development. Providing information on the additional mortgage costs attached to the mounting of a PV system and providing information on the financial yields in probable energy price development scenarios would create circumstances where installing a PV system would contribute to a decrease in costs (mortgage + energy bill), given that the system would have a break-even point of less than about 20 years. This would provide a good opportunity to integrate PV systems into the building and financing process, especially in the context of new buildings.

Nonetheless, existing buildings can also yield opportunities for the stimulation of the adoption of PV systems. Energy suppliers could be envisaged as developing some kind of leasing contract, where the revenues of the PV systems balance the costs of the PV system. Obviously, from a purely financial perspective, these solutions do not optimise return on investment, as investing in stocks will probably yield better than using a mortgage or lease construction to buy a PV system. On the other hand, empirical data clearly show that problem awareness is also a major factor determining the purchase of a PV system. Were financial barriers adequately removed, the purchase of a PV system might become easier. Due to social network effects, the installation of a PV system could become a normal point for consideration when buying a new house.

To summarise, the results as presented in this paper suggest that policy measures aimed at promoting the adoption of PV systems have to target the relevant barriers obstructing the adoption of PV systems and the various motives stimulating consumers to buy a PV system. In this respect, some policy measurements have to target the population as a whole, for example problem awareness (mass medial campaigns) and financial arrangements, while other measurements have to target specific groups (viral marketing), for example by supporting people with high-problem awareness, and preferably familiar with the bureaucratic procedures and the installation of PV systems, thus removing barriers that may give rise to cognitive dissonance effects. In subsequent policy measures, the adopters could be used as 'examples', stimulating people in the social network of adopters to consider adopting a PV system. For example, adopters could receive a reward for stimulating other people to adopt, for example a financial bonus, a small gift or a reference in a local newspaper. The combined use of such measures seems essential to reach a critical mass of PV owners, which is essential to 'normalise' the possession of a PV system, thus facilitating the further diffusion of PV systems.

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