The Relative Importance of Aesthetics in the Adoption Process of Solar Panels in the Netherlands

Conference Paper · August 2016

CITATIONS
0

READS
39

3 authors, including:

Ad Breukel
Breda University of Applied Sciences
24 PUBLICATIONS **19** CITATIONS

SEE PROFILE

The Relative Importance of Aesthetics in the Adoption Process of Solar Panels in the Netherlands

Ad Breukel[1], Chantal van Dijk[1] and Karel Spee[1]

[1] Avans University of Applied Science, 's-Hertogenbosch, The Netherlands

awv.breukel@avans.nl

Abstract: This study focuses on the possible advantage of an aesthetic appeal on the adoption of photovoltaic (PV) cells and panels. During the last decade, we have seen an impressive rise of installed PV capacity in the form of crystalline silicon-based panels. At present times, these conventional panels are foremost delivered in a blue or black version that, according to potential buyers, may disturb the appearance of their houses. This perception of solar panels could hamper future market growth.

Our study deals with the importance of this perception of solar panels by potential buyers. It reports the relative importance of aesthetics compared with other attributes, namely investment costs, payback period, reliability and expected services as experienced by homeowners. It shows various consumer segments with different preferences about the adoption of solar panels. Consumers in the main segment value aesthetics the highest, where consumers in another important segment attach most value to a high service. In addition to that, our study shows that investment costs are relatively unimportant in the first stages of the adoption process of solar panels. Finally, a subsequent market simulation demonstrates market growth opportunities of nearly fifty percent for aesthetic alternative solar panels.

We conclude that the decision to adopt solar panels is determined by more factors than just the investment costs. These results are not in line with the general perception of the installers. They also partly contradict other studies on aesthetic applications versus investment costs of solar panels. A first exploration of reasons for this divergence hints at the importance of the different stages of the purchase process in which the respondents of the studies are located. Therefore, we recommend further study on the role of purchase stages in order to explain the adoption of solar panels.

1 Context: a new generations of solar panels

At present times, a growing number of roofs of houses are covered with solar panels but they are still greatly outnumbered by houses without these panels. Several reasons why homeowners do not choose for solar panels are: the price-level (W/E adviseurs, 2015), financial uncertainties about the payback of these solar panels (Motivaction, 2011) and the fact that panels are not considered as "nice-looking" (Ponte , 2015).

Many of the present solar modules are installed at existing tiles. We refer to them as "add-on modules". These modules offer only a small choice in size and color, namely blue or black. These standard dimensions of the solar panels cause problems when they cannot be fitted upon an individual roof. It is also difficult to affirm this add-on modules around a dormer or chimney. The

Solar Trend Report 2014 (Solar Solutions, 2014) refers to one of the new trends, namely that consumers increasingly ask for aesthetic solutions. At the moment, several studies are conducted to integrate solar devices within a roof in order to reach an aesthetically superior roof. Other studies focus on flexible add-on modules with a wider color range or wider dimensional sizes and forms to attain the same aesthetic impact.

The goal of our study is to provide insight into the motives of customers to select innovative, aesthetic solar panels. What are their motives, and to what extent are they willing to pay extra for nice-looking solar panels? The use of the theory of acceptance processes may offer new insights to the relative importance of aesthetics in relation to other selection criteria of solar panels.

2 Attributes for the adoption of solar panels

This study applies a modified version of Unified Theory of Acceptance and Use of Technology (UTAUT2). The UTAUT2 model is effective in research on consumer behavior with regard to the acceptance of a new technology. So far, stakeholders in the solar and construction sectors, and in particular the installers, have the perception that the consumer is not willing to pay extra for a different option than the default modules; therefore they view more costly aesthetic variants as unattractive (W/E adviseurs, 2015; Ponte, 2015; Motivaction, 2015).

Previous consumer research (e.g. at mobile Internet devices) has revealed that more factors have an impact on the acceptance of a technology in addition to the expected performance and expected effort (Venkatesh et al., 2012). We apply the UTAUT2 model in order to verify the selection of solar panels amongst consumers. Hedonistic motivations are taken into account because we expect that they will affect behavioral intentions. In addition to that, price value is taken as a relevant factor for the purchase decisions of consumers with respect to technology. In order to measure the degree of the acceptance of solar panels, we introduce the following attributes that influence their choice.

2.1 Price

The cost of purchasing a solar system is the first attribute that is extensively discussed in the literature (Sidiras & Koukias, 2004; Watson, Sauter, Bahaj, James Myers & Wing, 2006; Caird, Roy & Herring, 2008; Zhang, Shen and Chan, 2012). This includes the cost of PV panels, mounting hardware, circuit breakers, inverters and cables (Zhang, Shen and Chan, 2012). The various studies show that the high investment, or even the perception of consumers that solar is expensive, provides a barrier to the adoption of solar panels (Arkesteijn & Oerlemans, 2005).

2.2 Payback period

The price is related to another frequently mentioned attribute, namely the payback period. This is the period between the moment of the investment until the moment this investment is recouped through revenues coming from this investment (Zhang, Shen and Chan, 2012). In general it is stated that, the higher the initial cost, the longer the payback period, assuming identical returns. This long payback

is confirmed by several studies as a major barrier to the selection of solar panels (Sidiras & Koukios, 2004; Watson et al., 2006; Caird, Roy & Herring, 2008; Zhang, Shen & Chan, 2012).

2.3 Reliability of the performance of the system

One of the technical issues for the (non-) selection of solar panels is the unknown reliability of the operation of the technology. Reliability refers to the annual number of incidents, defects or problems related to the installation. Proven cost-effective technologies such as renewable energy, are still seen as risky because there is little experience with such new applications (Beck & Martinot, 2009). Some studies (Watson et al., 2006; Caird, Roy & Herring, 2008; Mirza, Ahmad, Harijan and Majeed, 2009) have shown that this uncertainty about the reliability, caused by the lack of understanding of the systems and familiarity with the new form of energy, slows down the selection of solar cells.

2.4 Expected service

Another issue that has a negative impact on the adoption is the uncertainty about finding a reliable installer (Caird, Roy & Herring, 2008) and lack of well-trained installers (Mirza et al., 2009). The lack of knowledge and information about the level of service may increase perceived uncertainties and so block decision-making (Beck & Martinot, 2009). This uncertainty also stretches to general provided services such as the reaction time to solve problems concerning PV installation.

2.5 Aesthetics

If product alternatives are equal in functionality and price, consumers will choose the product which is the most attractive in aesthetic sense (Creusen & Schoormans, 2005). Our research applies the definition of aesthetics as "for the eye beautiful things, because they are in harmony with the environment and this makes it a pleasure to watch (Kootstra & van der Zwaal, 2006; Holbrook & Zirlin, 1985). The aesthetics of a product can result in significant influence on consumer behavior. An improved or innovative product appearance is advantageous in certain commercial purposes, or for commercial products such as solar panels(Veryzer, 1993).

A number of studies have indicated that aesthetics is a key factor for the adoption of solar panels. One of these studies has concluded that the adoption rate of solar cells decreases if they negatively impact the visual landscape or appear too pushy (Faiers & Neame, 2006). Also Sidiras and Koukios (2004) indicate that the non-aesthetic character of the current solar panels is a barrier for their purchase.

People differ in their perception of beauty so that consumers differ in the degree of acceptance of an innovation based on aesthetics. (Kootstra & van der Zwaal, 2006). Especially the groups that are referred to as innovators and the early adopters, appreciate the appearance of the product and attach the most importance to aesthetics. This means that aesthetic design has a positive impact on the acceptance of a new product in these groups (Yamamoto & Lambert, 1994).

We conclude that, although price is an important decision-making criterion for the selection of solar panel, many attributes are seen in the literature as relevant. Therefore we design our method of study to assess the simultaneous impact of these attributes upon the adoption process of solar panels in order to find preferences of different groups of homeowners.

3 Method of study

Based on the literature and the pilot test, the items investment costs, payback period, aesthetics, reliability and expected services are expected to determine the choice of solar panels and are therefore included as attributes in a conjoint analysis. The purpose of a conjoint analysis is to find the relative importance of various product attributes (Green & Srinivasan, 1978). Conjoint analysis, and in particular the choice-based conjoint variant, is a useful method for the development of technical products such as solar panels (Van Kleef et al., 2005). We ask respondents to make trade-offs between more and less aesthetic solar panels (a pairwise comparison method). Each respondent receives eight choice sets and must, each time, choose between two (hypothetical) options. This choice set refers to a realistic product, that is a combination of the above-mentioned five product attributes. The scores for each attribute are shown in Table 1.

Attributes	**Attribute level 1**	**Attribute level 2**
Investment costs (per 30 m^2)	Low costs *(€6000)*	High costs *(€9000)*
Payback period	Short period *(6 years)*	Long period *(9 years)*
Aesthetic	Low *(no match in shape and color)*	High *(match in shape and color)*
Reliability	Low reliability *(≥ 1incidents/failures per year)*	High reliability *(no incidents/failures per year)*
Expected services	Poor service *(slow, not clear and sometimes incorrect service)*	Good service *(rapid, transparent and accurate service)*

Table 1: Attributes with associated attribute levels

We offer the respondents illustrative images of the roofs with solar panels (visuals) in the choice-sets. The conjoint analysis applies a convenience sampling technique to recruit the needed number of respondents with the condition that the respondent possesses a house with an own roof.

4 Results

In total, 231 respondents completed the survey. Of these 231 respondents, 213 persons have answered the question "do you own your home" positively. We continue our analyses with these 213 respondents. This number is within the range of 200 to 300 minimally required completed surveys, a regularly applied rule-of-thumb of the conjoint analysis, and sufficient for developing hypotheses about a market (Orme, 2010).

A three segment model (as shown in Table 2) was the best fit with the data as defined by the latent gold choice program. We describe these segments below.

	Segment 1 (40%)	%	Segment 2 (32%)	%	Segment 3 (28%)	%
Investment costs	0.0236	2%	0.0965	10%	0.0269	3%
Payback period	0.0661	7%	0.0432	4%	0.1060	11%
Aesthetics	0.5913	60%	0.2048	20%	0.0602	6%
Reliability	0.1057	10%	0.1579	16%	0.1254	12%
Expected services	0.0874	9%	0.1958	20%	0.1647	16%
No choice	0.1259	12%	0.3018	30%	0.5169	52%

Table 2: Relative importance of the attributes by segment[1]

4.1 Segment 1: aesthetics caring consumers

The major part of the consumers (40%) is classified as aesthetics caring consumer. Consumers in this segment value the aesthetics of solar panels as the highest selection criterion. Here, aesthetics is seen as the most important factor (60%), while the consumer favors in 96.2% of cases a high level of aesthetics. If it is not possible to select nice-looking solar panels, they will not choose solar at all.

4.2 Segment 2: choosy consumers

It not very clear to what attribute the consumer in this segment (32%) attaches the most value. People in this segment find it important to be able to choose the “no choice” option, meaning that they do not prefer the different choice sets. This may also indicate that this segment is very picky.

4.3 Segment 3: consumers that prefer certainty

Consumers in this segment (28%) prefer solar panels with a short payback period, high reliability and good service. They also attach high importance to the "no choice option" but the majority (98,7%) chooses, in the end, for solar panels.

Based on the profiles of these three segments we conclude that the consumers can be approached with an aesthetically shaped solar product with high service. It is realistic that the price is relatively higher and the payback period is relatively longer than those of the standard panels. This type of solar panel will have a lower reliability level due to its newness. This product is interesting for the aesthetic caring consumers because of its high aesthetic design, but also the consumer that prefer certainty will favor it because of its high level of service. We conduct a market simulation to verify the level of market growth by the introduction of the aesthetic solar panels.

4.4 Market simulations

The first market analysis describes the current situation, where two options are compared: the “no choice” option versus the standard solar panels. Table 3 demonstrates that 51.3% would choose the standard panels.

[1] Table 2 shows three segments with their relative size and perceived importance of individual attributes such as reliability and so on as perceived by respondents. It does not reflect choices on their level (high-low, etcetera).

		Segment 1	Segment 2	Segment 3	Total
Standard PV		46,1%	14,7%	99,7%	51,3%
	€6000 investment costs 6 year payback period Low aesthetics High reliability High expected services				
No choice		53,9%	85,3%	0,03%	48,7%

Table 3: Market simulation for standard solar panels, per segment and in total.

Table 4 shows the second market analysis with the "no-choice" option, the standard panels and the aesthetics solar panels, which are described with their corresponding properties. A high number of the consumers, namely 43.7%, would choose the new, aesthetic panels and 31.0% selects the standard panels (a total of 74.7%).

		Segment 1	Segment 2	Segment 3	Total
Standard PV		9,2%	11,4%	83,9%	31,0%
	€6000 investment costs 6 year payback period Low aesthetics High reliability High expected services				
Aesthetics PV		80,0%	22,7%	15,9%	43,7%
	€9000 investment costs 9 year payback period High aesthetics Low reliability High expected services				
No choice		10,8%	65,9%	0,02%	25,3%

Table 4: Market simulation for standard solar panels and aesthetic solar panels, per segment and in total.

So, only 25.3% of the consumers do not choose panels at all, which is 50% less than the "no choice" consumers in the first market analysis. The aesthetics caring consumers choose this aesthetic option with a clear majority (80.0%). The choosy consumer still prefer the "no choice". Finally, the majority of the certainty consumers (83.9%) still prefers the standard panels, probably because of its high reliability. Summarizing, the introduction of the product offers a market growth for solar panels of 45.6% (((74.7% - 51.3%) / 51.3%) * 100).

5 Conclusions

Our study shows a surprisingly positive picture about the appreciation of aesthetics. Consumers of segment one experience a significant need for aesthetics. They state that aesthetics is an important attribute and choose for a high aesthetic variant. They even consider aesthetics as the key factor that determines their choice of innovative solar panels. The willingness to choose solar panels will be more positive if there is a high aesthetic option.

In segment two and three the importance of aesthetics is viewed as a less important feature, but when giving the possibility, consumers choose for the more aesthetic option – so these segments do not contradict the attention for aesthetic solar panels. Consumers in segments two can be characterized as picky. Their preference-level of all attributes is of an approximately equal size. The certainty preferring consumer in segment three values aesthetics as lowest attribute, compared with the other segments. This consumer determines his choice on the basis of the reliability and the expected service of the solar panels.

Some of our results contradict the attention for price and financial returns as main buying criteria for solar panels, which is found in previous studies (Motivaction 2015; Ponte in 2015 with reference to Stolks/MilieuCentraal 2014). A recent study shows that installers assume that consumers tend to choose for the lowest price and also are not willing to pay more for another, more aesthetic form of solar panels (W/E adviseurs, 2015). However, we have shown that the choice to select solar panels depends on more factors than their price only. Our conclusion is contrary to this idea of installers. A reason for this difference may be that the several studies (W/E adviseurs, 2015 Ponte; 2015; Motivaction, 2015) and our study are in different stages of the buying process. Our study, for instance, focuses on the awareness stage for the AIDA model and not the use behavior stage of the UTAUT2 model that refers to the actions AIDA action stage. The impact of aesthetics becomes particularly evident in the market simulations that demonstrate a 45.6% market growth when factors such as aesthetics and service are given attention to. We suggest to inform installers that there are different consumer needs; an expansion of the variety of the supply of solar panels while addresses the various needs of consumers, may result in a larger market.

Based on these market opportunities, we recommend further study on the importance of the stages, in which the potential buyers are located, for the weighing of the various buying criteria. Especially the impact of the provision of specific providing decision-making information to the possible consumers of different segments in the different stages of the buying making process, could shed more light on the better adoption of various types of solar panels.

This study has some limitations. As stated before, the results of the conjoint analysis may differ from real purchase decisions. The choice sets for the respondents are a simplification of the reality. Besides, respondents may not take all attributes and attribute levels into account for his decision. We have tried to avoid this by not including many attributes in the choice sets. Furthermore we have not linked demographic data such as income class with the three segments. Another limitation is that the conjoint analysis contains pictures of roofs with solar panels. This usage of visuals may distract the attention from the verbal information too much, leading to a situation where a respondent selects a particular option because of the preference for the image instead an objectively evaluation of the product. (Couper, Tourangeau & Kenyon, 2004). We suggest a follow-up study to perform a more extensive pre-test of the images in order to determine whether these images are considered as equally attractive.

References

Arkesteijn, K., & Oerlemans, L. (2005). The early adoption of green power by Dutch households: An empirical exploration of factors influencing the early adoption of green electricity for domestic purposes. *Energy Policy*, *33*(2), 183-196.

Beck, F., & Martinot, E. (2004). Renewable energy policies and barriers. *Encyclopedia of energy*, *5*(7), 365-383.

Caird, S., Roy, R., & Herring, H. (2008). Improving the energy performance of UK households: Results from surveys of consumer adoption and use of low-and zero-carbon technologies. *Energy Efficiency*, *1*(2), 149-166.

Couper, M. P., Tourangeau, R., & Kenyon, K. (2004). Picture this! Exploring visual effects in web surveys. *Public Opinion Quarterly*, *68*(2), 255-266.

Creusen, M. E., & Schoormans, J. P. (2005). The different roles of product appearance in consumer choice. *Journal of product innovation management*, *22*(1), 63-81.

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

Green, P. E., & Srinivasan, V. (1978). Conjoint analysis in consumer research: issues and outlook. *Journal of consumer research*, 103-123.

Holbrook, M. B., & Zirlin, R. B. (1985). Artistic creation, artworks, and aesthetic appreciation: Some philosophical contributions to nonprofit marketing. *Advances in nonprofit marketing*, *1*(1), 1-54

Kootstra, G. L., & van der Zwaal, J. (2006). *Designmanagement: design effectief benutten om ondernemingenssucces te creëren*. Pearson Education.

Mirza, U. K., Ahmad, N., Harijan, K., & Majeed, T. (2009). Identifying and addressing barriers to renewable energy development in Pakistan. *Renewable and Sustainable Energy Reviews*, *13*(4), 927-931.

Motivaction. (2011). *Helft Nederlanders wil zonnepanelen op dak.* Stichting Natuur en Milieu. http://www2.natuurenmilieu.nl/nieuws/perscentrum/20110621-helft-nederlanders-wil-zonnepanelen-op-dak/.

Motivaction. (2015). *Energievoorziening 2015-2050: publieksonderzoek naar draagvlak voor verduurzaming van energie & Profielen – Duurzame opties.* https://www.rijksoverheid.nl/documenten/kamerstukken/2016/01/18/kamerbrief-energierapport.

Orme, B. (2010). *Getting started with conjoint analysis. Studies for product design and pricing research*. Second edition, Madison, Wis. Research Publisher LLC.

Ponte, E. (2015, maart). Drempels bij consumenten? Neem ze weg! *Solar Magazine*, *5*(3), 65.

Rogers, E. M. (2010). *Diffusion of innovations*. New York. Simon and Schuster.

Sidiras, D. K., & Koukios, E. G. (2004). Solar systems diffusion in local markets. *Energy Policy*, *32*(18), 2007-2018.

Solar Solutions. (2014). Zonnestroom: van niche naar impact. *Solar Trend Rapport 2014*, 47.

Venkatesh, V., Thong, J. Y., & Xu, X. (2012). Consumer acceptance and use of information technology: extending the unified theory of acceptance and use of technology. *MIS quarterly*, *36*(1), 157-178.

Van Kleef, E., van Trijp, H. C., & Luning, P. (2005). Consumer research in the early stages of new product development: a critical review of methods and techniques. *Food quality and preference*, *16*(3), 181-201.

Veryzer, R. W. (1993). Aesthetic response and the influence of design principles on product preferences. *Advances in Consumer research*, *20*(1), 224-228.

Watson, J., Sauter, R., Bahaj, A. S., James, P. A. B., Myers, L. E., & Wing, R. (2006). Unlocking the Power House: Policy and system change for domestic micro-generation in the UK.

W/E adviseurs (2015). *Inventarisatie esthetische inpassing zonnepanelen: Een onderzoek naar mogelijkheden en belemmeringen voor esthetische inpassing van zonnecelpanelen in de bestaande bouw* (Rapport Nr 8755). http://www.rvo.nl/file/rapport-inventarisatie-esthetische-inpassing-zonnepanelenpdf.

Yamamoto, M., & Lambert, D. R. (1994). The impact of product aesthetics on the evaluation of industrial products. *Journal of Product Innovation Management*, *11*(4), 309-324.

Zhang, X., Shen, L., & Chan, S. Y. (2012). The diffusion of solar energy use in HK: What are the barriers?. *Energy Policy*, *41*, 241-249.