From vague interest to strong intentions to install solar panels on private homes in the North – an analysis of psychological drivers

Abstract

Solar panels have not seen the same widespread adoption in the Nordic countries as in the rest of Europe. The aim of the paper is to investigate how house owners that have already expressed some interest in solar panels form an intention to become pilot customers in an innovative scheme to install solar panels. The main theoretical perspective for the analysis is the Theory of Planned Behaviour, expanded by descriptive norms and innovativeness as a personality trait. The data was collected using an online survey, and data from 577 participants was analysed. The sample consists of individuals that took an active step towards installing solar panels on their residence by responding to a call from a local energy provider. The results show that perceived behavioural control has the biggest influence on intention. Moreover, being innovative influences intention positively while being sceptical to innovation has a negative effect. Attitudes, however, have only marginally significant impact on intention in this target group. The results from this paper can provide suggestions for shaping pro-solar panel messages toward the target group of people positive to solar panels but not yet decided to install.

Keywords: Climate psychology; Solar panels; Nordic; PLS-SEM; Consumer behaviour; Theory of planned behaviour.

1. Introduction

Compared to other high-cost pro-environmental technological products like electric cars or heat pumps, adoption of solar panels has been rather limited in Nordic countries. This is in stark contrast to other European countries. For example, in Germany, 120,000 households and small businesses have installed solar power systems [1]. In 2018, only a small amount of the households in Norway had invested in solar panels [2]. The total installed capacity in Norway at the end of 2015 was fifteen MW [2]. Low adoption rates of solar panels in Norway seem to prevail despite scientific evidence showing that solar panels will be effective also under Nordic conditions [3].

By analysing data from respondents to a residential solar panels initiative organized by a Norwegian power company, we attempt to identify significant psychological factors which influence the intention to become a pilot customer for a residential solar power system. The initiative of the energy provider was to pilot a solar panel product where the energy provider would own and maintain the solar panels installed on private single homes and rent the installation to the owner of the house, whereas the houseowner would use the produced electricity and benefit from potential revenues the solar panels would generate. In the local newspaper, the energy provider presented their plans and asked interested house owners to register in a database. The researchers behind this study then had the opportunity to send a link to an online survey to the interested people. Studies on such a target group are limited in Nordic countries, but also beyond. Focusing on individuals who have already shown some interest in solar panels makes it possible to see how more concrete intentions are formed from initial interest. This can provide important information to frame campaigns targeted toward groups of people that might consider investing in solar panels, especially in getting them from initial interest to intention to actually install panels.

There have been several studies [4,5,6,7] examining factors influencing either the intention or investment behaviour related to solar panels. Nath [4] confirmed the role of norms, attitudes, and perceived behavioural control on the intention to adopt residential solar panels. In their paper on how to accelerate the demand for residential solar panels, Wolske et al. [7] found that the framing of the

message is important for adoption. They also point out that the most efficient way to promote solar panels might change depending on where in the innovation diffusion process this innovation is.

2. A theoretical approach to solar panel adoption

A wide variety of factors, both personal, social, and societal, are affecting pro-environmental behaviours like adopting electric cars and residential solar panels [4]. Among the socio-psychological theories, the Theory of Planned Behaviour (TPB, see [8]) is one of the most used theoretical frameworks to explain pro-environmental behaviours. A meta-analysis of TPB based on 185 studies [9] showed that TPB explains on average 31% of variance in self-reported behaviour and 20% of variance in observed behaviour (see also [10,11]).

TPB incorporates attitudes, subjective norms, and perceived behavioural control (PBC) which together form a behavioural intention, which directly predicts the behaviour in question [8]. Attitudes are an amalgamation of all outcome beliefs that are related to the behaviour in question [12]. Attitudes have been found to be a strong predictor of high-cost pro-environmental behaviours in several papers [7,13,14,15]. Subjective norms are described as "perceived social pressure to perform or not to perform the behaviour" [9, p.188]. However, subjective norms are not commonly seen as a strong predictor for behaviour [16]. PBC is best described as a belief about whether a person feels able to perform certain behaviour in a specific context [9]. Wolske et al. [7] found that in both TPB and in an integrated model created to explain the interest in adopting residential solar panels in the U.S., PBC was a significant predictor of interest in talking to an installer of solar panels. This finding is especially relevant in the context of the present research as it marks a similar point in decision making as we studied. The final component of the TPB – intention – can be viewed as plans that in parallel with opportunities and resources enable us to achieve our goal [17]. In other words, in the TPB, intention is meant to encompass the different motivations that influence our behaviour [9].

Although the TPB is a parsimonious model that improves our ability to predict behaviour, it is "open to the inclusion of additional predictors if it can be shown that they capture a significant proportion of the variance in intention or behaviour after the theory's current variables have been taken into account." ([9], p. 199). As one of the theoretical additions, Rogers's [18] Diffusion of Innovations theory (DOI) has been employed to contextualize the findings on pro-environmental technological products where diffusion dynamics through a population might be relevant [4]. Since residential solar panels are relatively new in Norway, innovativeness is included as an additional predictor in the present model. Innovativeness captures the rather stable trait of a person reflecting the tendency to either embrace innovations (both technological and social) or to be more sceptical towards them. This trait is assumed to be relevant for the level of risk a person is willing to take with respect to adopting innovations. TPB does not cover innovation, only decision making. Including innovativeness from DOI lets us asses the importance of innovativeness and scepticism, and how this influences the adoption of solar panels in the step from coming from a vague interest to more concrete planning.

Diffusion in this context is described as a form of communication in which innovation is shared through different channels over time between members of a social system [18]. In order of timing of adoption, Rogers categorized adopters of innovations as innovators, early adopters, early majority, later majority, and laggards. *Innovators* are individuals who accept a great deal of uncertainty and risk because they are open to newer ideas and technologies. The second group, *early adopters*, might have leadership roles and are often approached for advice. Thus, their opinion of the innovators and the innovation itself is of great importance to the diffusion of the innovation. This group plays an important role in giving the innovation credibility. The *early majority* is the first large segment of the population to adopt the innovation. As opposed to the early adopters they do not have leadership roles. However, their adoption helps the diffusion process. The *late majority* consists of the individuals that wait with the adoption of an innovation until the innovation has become common. Their reason for

adopting could be out of necessity as to not fall too far behind. The final group of innovation adopters are known as *laggards* and are traditional and sceptical towards innovations. Their social system often consists of people that share a similar mindset [19]. This limits their knowledge of the innovation, especially when it comes to awareness-type knowledge. Laggards also want to make sure that other people have successfully adopted the innovation before they start using it [18].

Extension of the TPB with innovativeness from DOI in the present paper is also within the scope of previous research. Several studies have used diffusion of innovation factors to explain the spread of environmentally friendly innovations. Wolske et al. [7] used innovativeness to explain the interest in talking to an installer of residential solar panels. Moreover, Ozaki [20] found that DOI can be used to explain factors that cause environmentally conscious individuals to not switch to green electricity.

Furthermore, several studies [21,22,23] have used descriptive norms as an extension to the TPB for explaining pro-environmental behaviours. Descriptive norms are formed when a person observes others' behaviours, which are often effective or adaptive in the context at hand [21,23]. In their meta-analysis, Rivis and Sheeran [24] presented twenty-one different hypotheses that all used descriptive norms as a predictor. They found that descriptive norms are a better predictor of intention than subjective norms. This could be an indication that observing behaviour might be more important than social pressure. They also showed that the effect of descriptive norms is lessened when people do not want to identify with the relevant group norms. Since descriptive norms are usually based on observed behaviour, increased adoption of solar panels in the neighbourhood may have a significant effect on the intention to become a pilot customer. However, it is possible that since there are few solar panels in Norway descriptive norms will have a negative effect on the adoption rate.

There are several expectations that we base our hypotheses on. We expect that the effects of attitudes, subjective norms and PBC are in line with TPB. This means that we expect the variables to predict intentions significantly. Further, we expect innovativeness to predict the intention to adopt solar panels. In addition, we expect descriptive norms to influence intention. Finally, we also want to explore whether social norms (both descriptive and injunctive) are more relevant for people who are less innovative based on the description of innovative types in DOI. To do this we test the interaction between norms and being innovative.

3. Materials and Methods

3.1 Participants and procedures

To examine the impact of factors on the intention to become a pilot customer of solar panels, a cross-sectional quantitative study via an online survey was undertaken in 2016. The variables included in the survey have been identified by the theoretical framework and validated by the empirical evidences mentioned in the previous section. The survey was a part of a pilot project on residential solar panels initiated by a Norwegian power company. All participants had initially shown interest to take part in the pilot project and were recruited from Central Norway through a newspaper article (see section 4.1 for descriptive information about participants).[1] These participants therefore took an active step in acquiring solar panels by registering in a database and expressing their interest to become pilot customers. This means that we are focusing on people who already have shown some initial interest in the topic. This is a particularly interesting group of the population when it comes to targeting messages that aim at increasing the use of solar panels. In total, 697 participants provided their

[1] After they registered their interests in the company's database, they were asked by the researchers if they were willing to answer the survey. Participation in or completion of the survey was not reported back to the company. The likelihood to be selected as a pilot customer was not related to participation or answers given in the survey.

responses to the questionnaire survey. However, after checking for completion and responses for variables under investigation, 577 cases were retained for analysis.[2]

3.2 Measures

The online survey consisted of a self-administered questionnaire. Questions were asked about the original TPB constructs and about descriptive social norms specified to the adoption of solar panels. In addition, participants' innovativeness was also measured. Questions about background information (e.g., age, gender, education, income and housing type) concluded the questionnaire. Participants were asked to give their response on a seven-point bipolar scale ranging from -3 to +3. For a full list of items used see Appendix A.

Attitudes toward adoption of solar panels were measured by "In general, you believe that getting solar panel on the roof would be …". Participants responded on a seven-point scale from "harmful/unpleasant/bad/worthless" (-3) to "beneficial /pleasant/good/valuable" (+3). Two items focusing on general environmental behaviour were used to measure subjective norms (e.g., "People that are important to me think that I should live as environmentally friendly as possible") and the answers ranged from "strongly disagree" (-3) to "strongly agree" (+3). Perceived behavioural control (PBC) was measured by three items about anticipated difficulties related to the installation of solar panels (e.g., "Solar panels increase the need to remove snow from my roof") and respondents' answers ranged from "little probable" (-3) to "highly probable" (+3). There are several ways to operationalize PBC [25,26], and there seems to be a lack of uniform operationalization of the PBC concept [27]. Based on the paper by Wolske et al. [7], our PBC items ask participants if they believe different aspects of solar panel ownership and acquisition will be a problem. In other words, the items look at different parts of the difficulty aspect specifically related to solar panels. This is an expansion to the question asked by Young et al. [26] where they present one item that asks if the behaviour is difficult. A single item, i.e. "How certain is it that you will say yes to become one of the pilot customers?" was used to tap the intention to adopt solar panels. The 7-point scale was anchored by "definitely certain to say no" (-3) and "definitively certain to say yes" (+3). Descriptive norms about installing solar panels were measured by two questions asking whether or not participants thought solar panels were common in the Trondheim region and in other Norwegian regions, respectively. The respondents' answers ranged from "very uncommon" (-3) to "very common" (+3). Twelve items from the Individual Innovativeness instrument developed by Hurt, Joseph, and Cook [28] were adopted to measure respondents' innovativeness (e.g., "I enjoy trying out new ideas"). The 7-point scale was anchored by "strongly disagree" (-3) to "strongly agree" (+3). These sets of items were divided into two factors, innovative and sceptical.

3.3 Statistical analysis

Partial least squares structural equation modelling (PLS-SEM), using the PLS-SEM package of STATA 16 [29], is employed as the primary analysis method. The PLS-SEM approach has been recommended under situations where the measurement model has several latent variables, which are measured with fewer items than recommended in the CB-SEM approach [30]. Further, the PLS-SEM's ability to handle single item constructs without model identification problems [31] lends flexibility to data analysis.

Our structural model is relatively simple. We hypothesize that the intention to adopt solar panels will be predicted by the TPB constructs (attitudes, PBC and subjective norms), and two additional measures, i.e. descriptive norms (on a local and national level) and participants' innovativeness (which

[2] There were 87 participants who did not complete the survey, and therefore were removed from the dataset. Following the recommendations by Hair et al. [31] additional cases were removed because they did not respond to a minimum of 85% of the questionnaire.

is divided into two factors, being sceptical or being innovative). Several socio-demographics are also included as control variables in the model. As these variables are added for control purposes, the results will not be presented in the results section (these variables can be found in Appendix A). To assess the measurement model, several criteria are used. The first is the size of the standardized loadings, i.e. standardized loadings above .70 are desired for indicators of latent variables. In other words, items that have standardized loadings below .60 are considered for removal. However, they should only be removed if the deletion leads to a composite reliability of above .70 [31]. The measurement model is also judged by composite reliability. According to Hair et al. [31], a Dillon-Goldstein's coefficient between .60 to .70 for exploratory research and .70 to .90 for more advanced stages of research is recommended. Following these criteria, specific items were removed from the analysis (see Appendix A). In addition, the validity of measurement models was examined referring to convergent and discriminant validity of the latent variables. An average variance extracted (AVE) value larger than .50 is considered satisfactory convergent validity. Discriminant validity is achieved if the AVE value of a latent variable is larger than the latent variable's highest squared correlation with any other latent variable [32].

The results of the path model will be used to reveal important factors that influence the intention to become a pilot customer of solar panels.

4. Results

4.1 Sample characteristics

The gender distribution in the sample skews heavily towards male, with 84.4% male and 15.6% female participants (see Figure 1). Mean age in the sample is 49.35 years. The sample is highly educated, with 71% of participants having tertiary education (see Figure 2). Ten percent of the participants live in an apartment. However, it is interesting that apartment dwellers show interest in becoming pilot customers even though their residence might not be suitable. Forty-nine percent of participants have a yearly household income of more than 1,000,000 NOK (approx. 107,900 Euros at the time of data collection). Only 19% have a household income that is less than 700,000 NOK (approx. 75,500 Euros). In short, this sample is rather homogenous, and mainly consists of middle-aged men who are highly educated and have a household income above the national income median [33]. Considering that our sample contains many homeowners, it is not a big surprise that household income is above the national median.

Figure 1

Gender distribution of participants

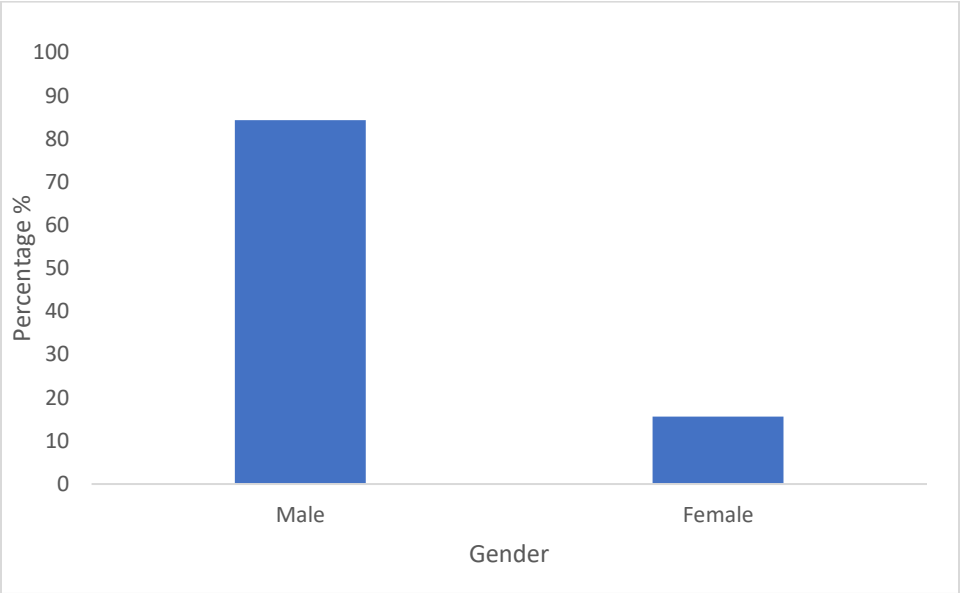


Figure 2

Distribution of participants education

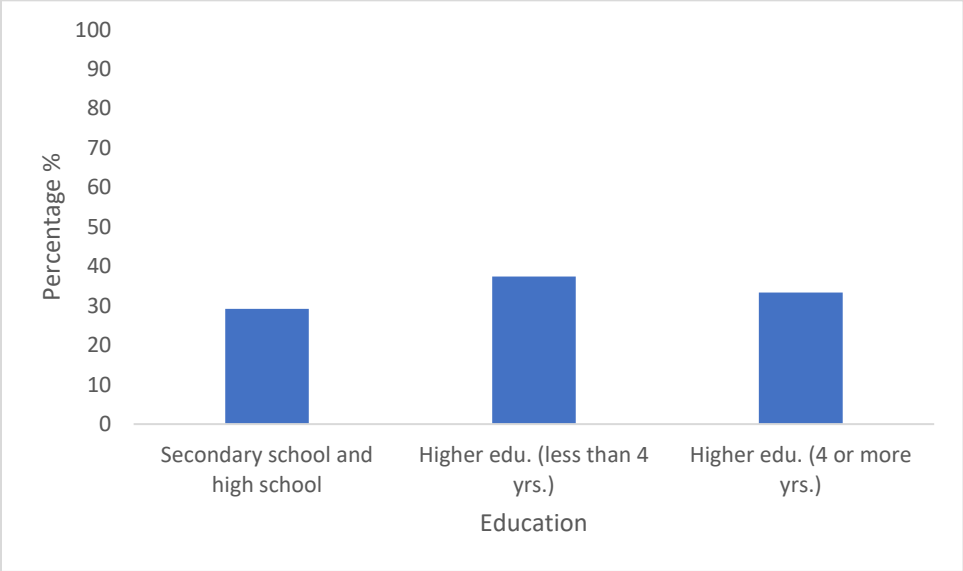


Figure 3

Distribution of Housing types of participants

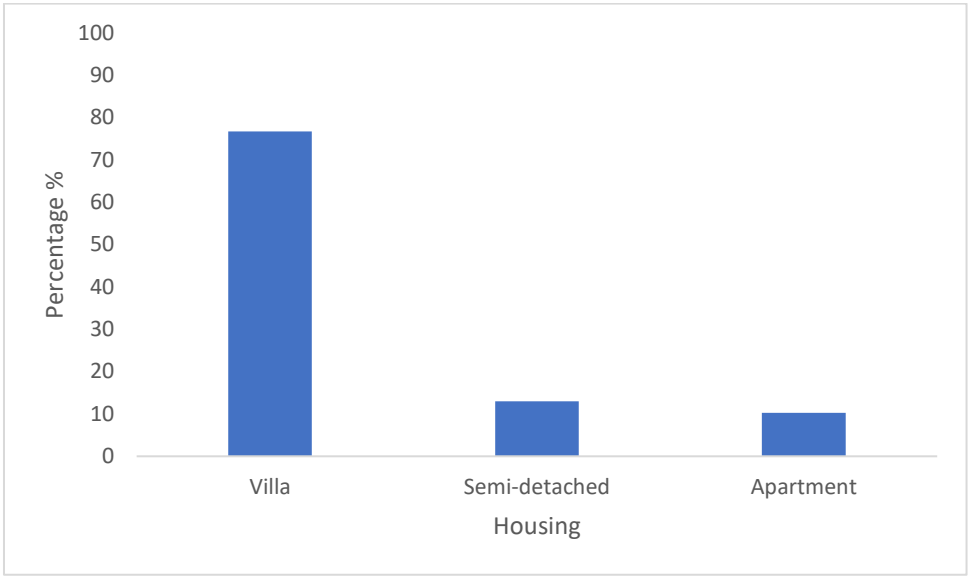
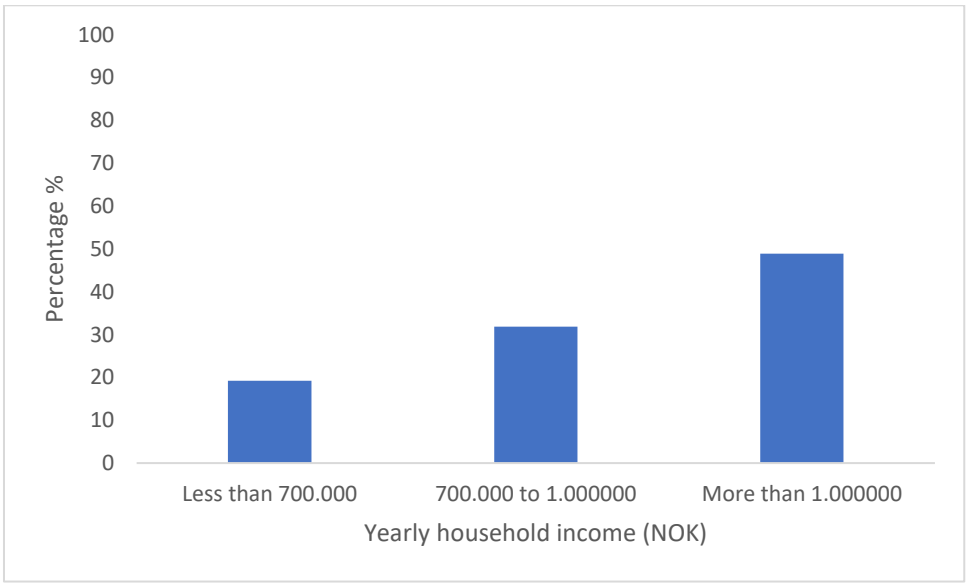


Figure 4

Distribution of yearly household income of participants



4.2 Measurement models of the latent variables

A preliminary PLS-SEM analysis was conducted first to verify the reliability and validity of the measurement models. The analysis indicated that four innovativeness items had to be removed because of low factor loadings (< .50) and cross-loadings. The analysis also showed that four PBC items had to be removed because of low factor loadings and cross-loadings. In addition, some descriptive norm items were removed as a result of low factor loadings. The modified measurement models exhibited satisfactory reliability at both indicator and construct level (see Table 1) and

convergent and discriminant validity (see Table 2), which are the prerequisites for assessing the path model of the study.

Table 1

Indicator and construct-level reliability of the measurement model

Items	Attitudes	Subjective Norms	PBC	Descriptive norms	Sceptical	Innovative	Intention
Attitudes 1	.847						
Attitudes 2	.845						
Attitudes 3	.914						
Attitudes 4	.850						
Subjective norms 1		.904					
Subjective norms 2		.765					
PBC 3			.897				
PBC 5			.621				
PBC 7			.679				
Descriptive norms1				.960			
Descriptive norms 2				.939			
Sceptical 1					.842		
Sceptical 2					.740		
Sceptical 3					.779		
Sceptical 4					.713		
Innovative 1						.787	
Innovative 2						.792	
Innovative 3						.699	
Innovative 4						.700	
Intention							1.000
DG	.922	.824	.782	.949	.853	.833	1.000
Rho	.969	.654	.848	.921	.803	.748	1.000

Notes: The table indicates standardized loadings for each variable, Dillon-Goldstein's coefficient (DG) and Jöreskog's Rho. PBC stands for perceived behavioural control. All items are listed in Appendix A.

Table 2

Convergent and discriminant validity of the measurement model: Squared interfactor correlations and AVE

Variables	Attitudes	Subjective norms	PBC	Descriptive norms	Sceptical	Innovative
Subjective Norms	.001					
PBC	.015	.000				
Descriptive norms	.001	.006	.026			
Sceptical	.004	.000	.037	.002		
Innovative	.012	.012	.008	.001	.119	
Intention	.016	.002	.181	.007	.043	.023
AVE	.746	.702	.550	.902	.593	.556

Note: AVE stands for average variance extracted

4.3 PLS-SEM path analysis

Table 3 provides the details of the path model results showing standardized path coefficients and confidence intervals of the latent variables predicting the intention to become a pilot customer of solar panels. The overall R^2 value ($R^2 = .22$) of the model is acceptable [34]. Among the TPB model constructs, PBC has a medium size effect ($\beta = -.37$) on intention and is significant ($p < .001$). The effect is negative which means that more perceived difficulties with the solar panel installation relate to less reported likelihood to become a pilot customer. Attitudes and subjective norms, however, fail to show significant impacts on intention.

Moreover, descriptive norms have no significant effect on intention. The variables related to innovativeness, i.e. both being sceptical and being innovative, have significant effects ($p < .01$) on intention. More specifically, being a sceptic has a negative impact on intention while being innovative has positive impact.

In addition, we tested the interaction between norms and being innovative. There was no significant interaction between descriptive ($\beta = .03$, $p = .723$) or subjective norms ($\beta = .05$, $p = .596$) and being innovative.

Table 3

PLS-SEM standardized path coefficients, *p*-values and confidence intervals of the latent variables predicting intention to adopt

Predictor variable	Standardized path coefficients	P-value	95% CI
Attitudes	.05	.103	.00 – .12
Subjective norms	.04	.435	-.06 – .14
PBC	-.37	< .001	-.43 – -.27
Descriptive norms	-.00	.891	-.08 – .08
Sceptical	-.10	.031	-.18 – -.02
Innovative	.09	.025	.00 – .16
R^2 adjusted	.22		

5. Discussion

The aim of the present study was to identify significant psychological factors important for increasing the adoption of private solar power systems among persons who already have shown some interest in such systems. By using an extended version of the TPB, predictors of the intention to become a pilot customer of solar panels were investigated.

The data analysis showed a significant effect of PBC on the intention to become a pilot customer of solar panels. This finding supports the notion that the perceived difficulty of the behaviour is important for the adoption decision, and it is consistent with other papers on the topic of solar power adoption [35,36,37]. In our sample, many participants believe that getting solar panels will not cause larger problems (i.e., they have high PBC) and are quite positive toward adopting residential solar panels as indicated by their attitudes. Our results are like those of Klöckner and Nayum [38]. They found that the closer an individual gets to behaviour implementation, issues like expected comfort levels, which are quite similar to the PBC we measured, were most important.

The intention to become a pilot customer of solar panels was also influenced by personal innovativeness. This is in line with Englis and Phillips [39] who showed that innovativeness was a significant predictor of intention. Our study shows that while being highly innovative positively affects intention, being sceptical has a negative impact. This effect can likely be explained by innovative people on the one hand defining their identity to a larger degree through the display of the newest technology (and solar panels are new at least in the Nordic context), and on the other hand through their higher willingness to take risks when trying new things (installing solar panels as a pilot customer is certainly connected to risk taking). However, it should be also noted that the study participants were those who already showed interest in this new technology (i.e., solar panels). Therefore, individuals who can be identified as sceptical could be underrepresented in the study. In a sample from the general population the number of sceptics would most likely be higher. In short, the findings confirm the role of personal innovativeness in adopting new technology solutions to environmental problems as opposed to being merely interested in these solutions.

The present study could not find significant effects of attitudes, subjective norms, and descriptive norms on the intention to become a pilot customer of solar panels. Although there is some empirical evidence showing attitudes as significant predictor of intention and behaviour [7,11,12,39] the results of the current study could only indicate marginally significant effect of attitudes on intention. This could be because participants in the present study have similar attitudes to solar panels since they have already shown some interest in the topic. Also, attitudes might be more important earlier in the decision process [40]. The participants might have moved past the point of attitudes influencing their decision. We would predict that attitudes had a strong influence to register in the database in the first place. It must be noted that in this study, no question specifically asked about study participant's attitudes to become a pilot customer and getting solar panels. Instead, several of the questions asked about the participant's attitudes towards solar panels in general. Like the attitudes measure, subjective norms items were also formulated in a general manner, i.e. about being environmentally friendly. However, it is plausible that environmental friendliness was not an important factor for our participants. As Ajzen and Fishbein [41] suggest, there should be high correspondence between measurements of the TPB constructs in order to increase the model constructs' predictive power. In addition, subjective norms require perceived social pressure [8].

Currently, there is no strong social and economic incentive for adopting solar panels in Norway as compared to electric vehicles for example [42]. It is a possibility that there is a negative social pressure in the broader population, and this is one of the factors that influences the adoption rate. Considering that residential solar panels have not yet become common in Norway, it is not surprising to find that

descriptive norms, which are formed by observing behaviours of others, had no effect on intention. This might indicate that most people in Norway do not believe acquiring solar panels is "normal". This is probably why the effects of the descriptive norms in this study were the lowest.

There are different ways in which policy makers can stimulate the adoption of residential solar panels. According to a study by Best and Burke [43], having supporting policies, such as carbon pricing, aggregate policy support, can increase adoption rates. Further evidence from Cargo and Chernyakhovskiy [44] shows that policy focusing on increased rebates was the most effective in increasing annual capacity add-ons. Policy that focuses on economic and ease of use factors could thus be instrumental in increasing the adoption rates of residential solar panels in Norway. However, a well-developed national policy concerning the adoption of solar panels is still lacking in Norway [45]. This has led to Norway lagging behind the rest of Europe. The reason behind the lack of policy on the matter in Norway could be due to Norway getting most of its electricity from hydro [46]. This, and the weather conditions, could lead to solar not being prioritised by the governing bodies. However, there is evidence that an increased adoption of solar panels in Norway and similar countries could be beneficial [3]. Research also shows that solar panels can be used in northern latitudes with sufficient efficiency to make their installation economically viable [3].

This study has some implications for future research and design of interventions aiming to increase adoption of private residential solar panels. The findings of the present study and similar studies carried out by others (e.g., [47]) give us an idea of what psychological factors should be in focus when attempting to promote widespread adoption of solar panels. Increasing PBC by removing perceived barriers is important as it would make people in the same position as our participants more willing to take the risk of adopting solar panels. Based on this it seems that the practical concerns surrounding solar panels are important. As expected, individuals scoring high on innovativeness would be more willing to accept new ideas and to try out new technology options. For development of early stage campaigns, this implies that appealing to innovative aspects of solar panels while providing effective ways of overcoming situational barriers can make a difference. Attitudes and social norms are not important at the stage in the adoption process that is investigated in this paper, but other studies suggest that they might be important in earlier stages of the decision-making process. This implies that it makes sense to tailor communication strategies to the different stages interested customers go through (see also Bamberg [48]), starting with arguing for the general benefits first, and when people become interested and start planning, to address their concerns about possible barriers to action. It could also be an interesting topic for further research to investigate if there is an effect of having an electric or hybrid vehicle on having an interest in solar panels or smarter home electric systems. A number of studies found that past environmental behaviour may be associated with an increase in intention to perform other environmental behaviours (see Maki et al. [49] for a meta-analysis). Such spill-over effects would also be of interest when studying adoption of electric vehicles and solar panels.

A possible limitation of this study is the age of the data used in the study (collected in 2016). However, we believe that the data is still relevant for a Norwegian context. For example, a paper by Winther, Westskog and Sæle [50] indicates that there has yet to be a large uptake in residential solar panels in Norway when their paper was written, and thus the situation with respect to residential solar panel adoption does not seem to have changed much in recent years (see also [51] It is important to note that there was a very large jump in installed capacity in 2019, however most of this was not residential.

The ratio between male and female respondents in our sample (approx. 84% male, see section 4.1) is something worth discussing. According to a meta-analysis by Cai, Fan and Du [52] females have a less positive attitude towards technology, which could be one of the reasons as to why we have a relatively low number of females in our sample. The source of this attitudinal gap is outside of the

scope of this article but Cai, Fan and Du [52] present arguments for why this is a multifactor issue. It is hard to say how a more equal gender distribution would influence our results. Previous research nevertheless seems to suggest that TPB variables and other socio-psychological variables often have fairly similar effects for men and women when it comes for example to adoption of electric vehicles [53] and pro-environmental behaviour more generally [54]. In a review paper on the decision making process behind household energy investments, Kastner and Stern [55] found that there was no clear systematic association between gender and household energy investments.

6. Conclusion

The aim of this paper was to assess effects of different psychological factors on the intention to become a pilot customer for a residential solar power system. Special attention was paid to persons that have shown a certain interest in this kind of residential power production. In general, three variables influenced the intention to adopt residential solar panels in this group. The first one, PBC, represents the importance of perceived difficulty when performing high-cost environmental behaviour. Secondly, being innovative seems to be indicative of increased intention to become a pilot customer. Third, being sceptical towards innovations had a negative effect on the intention to become a pilot customer. This indicates that scepticism towards environmental technology would hinder adoption. Additionally, attitudes toward solar panels were marginally significant. However, the effects of attitudes and norms are diminished, presumably as a result of the sample and the participants' stage in the adoption process. The findings could be used to find ways to promote the use of residential solar systems and other high-cost pro-environmental investments and tailor communication and support schemes specifically to getting interested people over the threshold to implement the technology.

Acknowledgements

We would like to thank Trønderenergi AS for allowing us to participate in their project and collect data.

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Appendix

Appendix A1. Full list of items both removed and used in the analysis

Variable	Variable description	Variable excluded?
Attitude 1	In general, do you believe that getting solar panels on your roof would be harmful or beneficial?	
Attitude 2	In general, do you believe that getting solar panels on your roof would be unpleasant or pleasant?	
Attitude 3	In general, do you believe that getting solar panels on your roof would be bad or good?	
Attitude 4	In general, do you believe that getting solar panels on your roof would be worthless or valuable?	
Subjective norms 1	People that are important to me believe I should live as environmentally friendly as possible	
Subjective norms 2	People that are important to me support that I live as environmentally friendly as possible	
PBC 1	Solar panels increase the need to remove snow from the roof	Yes
PBC 2	The construction will increase wear and tear on my roof	Yes
PBC 3	Solar panels will not be economically viable	
PBC 4	There will be a lot of noise when they are installed	Yes

PBC 5	There will be many everyday disturbances when they are going to be maintained by Trønderenergi	
PBC 6	The power supply to my house will be more unstable	Yes
PBC 7	There will be a lot of bureaucracy when it comes to getting the money that is a result of the production surplus	
Descriptive norms 1	Common solar panels – in the Trondheim region	
Descriptive norms 2	Common solar panels – in other Norwegian regions	
Innovativeness 1 (Sceptical)	I experience that I am often sceptical to new ideas	
Innovativeness 2 (Sceptical)	I am sceptical to new inventions and new ways of thinking	
Innovativeness 3 (Sceptical)	I am usually careful when accepting new ideas	
Innovativeness 4 (Sceptical)	I have to see other people use new innovations before I consider them	
Innovativeness 5 (Innovative)	I feel that I have influence among friends and colleagues	
Innovativeness 6 (Innovative)	My friends or colleagues often asks me about advice or information	
Innovativeness 7 (Innovative)	I enjoy trying out new ideas	
Innovativeness 8 (Innovative)	I see myself as creative in the way I think and behave	
Innovativeness 9	I improvise often ways to solve problems when the answer is not obvious	Yes
Innovativeness 10	I usually think that living and doing things in the traditional way is best	Yes
Innovativeness 11	I appreciate taking a leadership position in the group I belong to	Yes
Innovativeness 12	I think that it is stimulating to be original in the way I think and behave	Yes
Low education	Dummy variable based on education (value equal to 1 if education is “Common education”, 0 otherwise)	
High education	Dummy variable based on education (value equal to 1 if education is more than 4 years of university, 0 otherwise)	
Villa	Dummy variable based on housing (value equal to 1 if housing type is Villa, 0 otherwise)	

Detached	Dummy variable based on housing (value equal to 1 if housing type is Semi-Detached, 0 otherwise
Low income	Dummy variable based on yearly household income (value equal to 1 if income is less than 700.000 NOK, 0 otherwise
High income	Dummy variable based on yearly household income (value equal to 1 if income is more than 1.000000 NOK, 0 otherwise)
Gender	Are you a man/woman?
Age	How old are you?
Intention	The application to TrønderEnergi was noncommitting. How sure is it that you would say yes to become a pilot customer?

Note: For criteria used for item exclusion see section 3.3 in the paper. PBC stands for perceived behavioural control.