

**I'm Stocking (up) on Sunshine:
Behavior Change Determinants of Solar Panel Adoption**

Master Thesis



Universiteit Utrecht

Hannah Kuhlmann

1772546

Faculty of Social and Behavioral Sciences, Utrecht University

Master of Social, Health, and Organizational Psychology

Supervisor: Dr. Lieke Swinkels

Second Assessor: Dr. Manuel Barbosa de Oliveira

Due Date: 24th June 2022

Wordcount: 8.201

May be published after 29th July 2022

Abstract

This study tested the application of the information-motivation-behavioral skills (IMB) model in the context of solar panel installation for private households in Germany. Moreover, this elicitation research explored levels of information, motivation, and behavioral skills. Participants ($N = 138$) completed a questionnaire assessing knowledge, attitudes, social norms, behavioral intention, self-efficacy, and objective behavioral skills. Behavior was measured by summing the different behavioral steps to a solar panel investment decision that people had already taken. Mediation analysis using PROCESS revealed non-significant indirect effects of information and motivation through behavioral skills but direct effects of motivation and behavioral skills on behavior. Elicitation results suggest relatively high levels of information and motivation and deficits in behavioral skills with regard to solar panel installation, highlighting the importance of tackling behavioral skills in possible interventions. Future research should test the IMB model in the same context with improved measures of information, motivation, and outcome behavior and consider different target groups.

Keywords: Information Motivation Behavioral Skills-Model, Elicitation Research, Solar Panels, Behavior Change, Pro-Environmental Behavior

Climate change as a result of global warming is an issue of growing relevance and 2021 has clearly demonstrated its seriousness. Whether it is the flood disaster in Western Europe or raging wildfires in Southern Europe, its impacts have become noticeable even in regions that have previously been relatively spared. The fact that global warming is caused by human activities associated with greenhouse gas (GHG) emissions, is scientifically established (Hertwich & Peters, 2009; Masson-Delmotte et al., 2021; Oreskes, 2004). In order to limit global warming, the Paris Agreement requiring economic and social transformation has been signed by 196 parties (United Nations, 2015).

With the energy supply sector being responsible for the largest proportion of global GHG emissions (Ritchie & Roser, 2020), an important mitigation strategy in line with this treaty is a transition to renewable energies. Solar power has been emphasized as the “lowest-cost and most versatile power generation strategy” (SolarPower Europe, 2020, p.3) and in addition to its benefit of zero emissions, promoting the deployment of solar would also enable creation of many jobs (International Renewable Energy Agency, 2019). In Europe, Germany and Spain are one of the top five largest solar markets (SolarPower Europe, 2020), nevertheless, in comparison to fossil fuels, solar energy still remains one of the least used energy sources in both countries (Ritchie & Roser, 2020).

In order to further promote solar energy use, the installation of solar panels is a decisive behavior to be encouraged. Thereby, households represent an important target group as they are globally responsible for more than 70 percent of GHG emissions, energy use at home being a contributing factor (Hertwich & Peters, 2009). Even though individual behavioral change has been pointed out as a critical part of mitigating climate change (Creutzig et al., 2018), there is little research on individual energy-related choices and behavioral factors that may affect them. Therefore, this study aims to explore deficits in knowledge, motivation, and behavioral skills of solar panel installation in households in

Germany and Spain. By analyzing potential deficits in these factors, behavior change campaigns can be specifically tailored to the different populations and may ultimately contribute to a reduction in GHG emissions.

A model that captures information, motivation, and behavioral skills in the domain of behavior change is the information-motivation-behavioral skills (IMB) model which was first applied by Fisher and Fisher (1992) to health communications. It holds that there are three different determinants of performing and maintaining a specific behavior (Fisher & Fisher, 1992; Fisher et al., 2014): First, information about the problem, that is people need to have precise knowledge people about a problem and its accompanying consequences, as well as information about the target behavior in order to engage in the target behavior. Secondly, individuals need to be motivated to practice the behavior, and finally the target behavior is impacted by individuals' objective and perceived ability to perform the behavior (i.e., behavioral skills). Thereby, information and motivation may directly influence actions, but also indirectly impact the target behavior via behavioral skills. In other words, if individuals' levels of information and motivation are high, this most likely enhances their behavioral skills as well (see Figure 1). Accordingly, interventions developed on the basis of the IMB model aim to improve these determinants: Research on health-related behavior demonstrates that most effective interventions tackle all three in comparison to only one or two of the determinants (see review by Fisher et al., 2009).

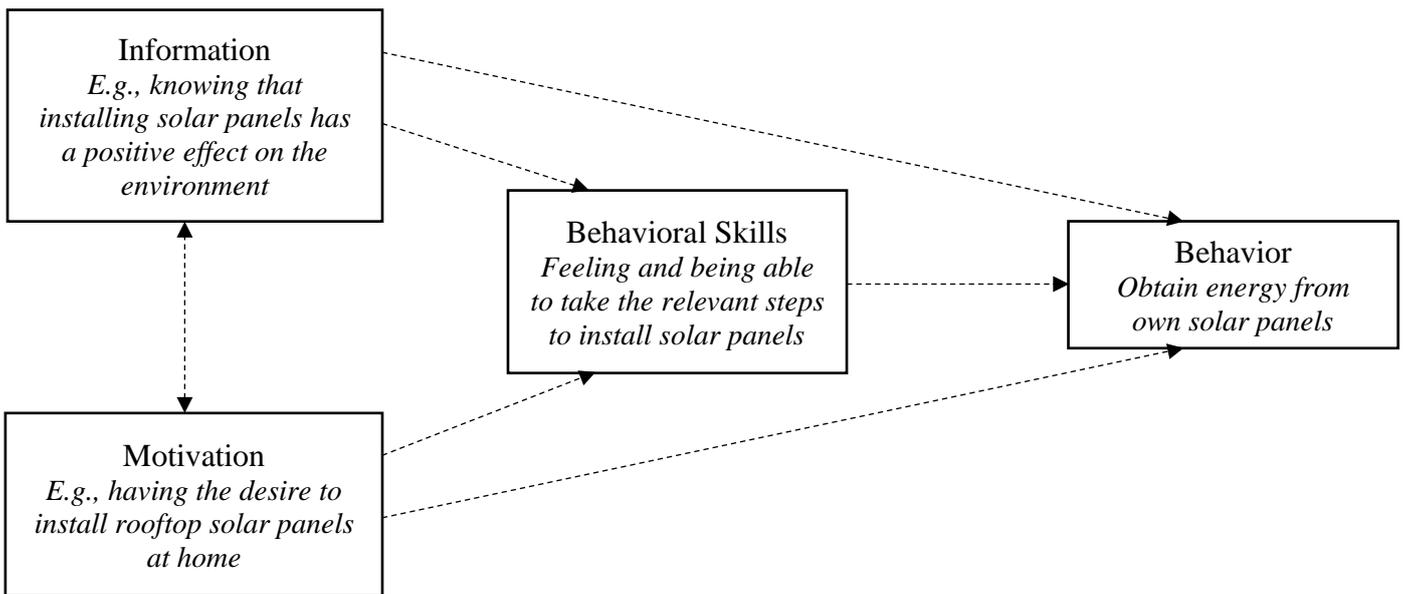


Figure 1: Information-motivation-behavioral skills model with solar energy adoption examples in italics.

Even though the model has mostly been applied in the health context so far, a recent review of household water conservation interventions, has drawn a link to a number of water conservation studies in which the three IMB factors may clearly be recognized and encourages the model's application in the context of sustainability psychology (Ehret et al., 2021). Consistently, a meta-review (Bamberg & Möser, 2007) identified several variables predictive of pro-environmental behavior in general such as information, attitudes, social norms, behavioral skills, and self-efficacy, which may clearly be defined as IMB predictors or at least fall within one of the constructs. For example, motivation is not clearly defined in the IMB model, however Fisher et al. (2018) mention the consideration of attitudes and social norms to identify by what the motivation to perform a behavior is driven. Finally, several similarities between health behavior and pro-environmental behavior may be noted which is another reason in favor of applying the model to sustainability psychology. For instance, the beneficial outcomes of both these behaviors are not immediately noticeable, if ever: taking the bike instead of the car will reduce the risk of developing heart disease as it will reduce

pollution. Nevertheless, these effects are not really tangible for individuals. Other overlaps mentioned by Seacat and Northrup (2010) are for example that both behaviors are motivated by the same intrinsic and extrinsic forces and that environmental problems may also have negative consequences for human health and “as such should be treated as significant health concerns” (p.395).

What makes the IMB model distinct from other behavior change models (such as the Theory of Reasoned Action by Fishbein and Ajzen, 1975) is that it highlights different phases of intervention design: elicitation, design and implementation, and evaluation (Fisher & Fisher, 1992). The model’s assumption is that each of the IMB constructs differ as the behavior and the population of focus change. That is why the elicitation phase in which the population-specific data are collected in order to subsequently tailor the intervention design in a way that it matches the population, is so important. Thus, in this phase deficits in information about the problem, motivational barriers, and behavioral skills limitations are identified. If for example, levels of knowledge and motivation are found to be high in this step and levels of behavioral skills are low, an intervention would focus on promoting behavioral skills. Furthermore, elicitation research enables us to identify existing strengths with regards to these variables which can be activated to facilitate behavior change. The importance of elicitation research has also been highlighted for intervention research in general: “We cannot understate how essential elicitation research is to the design of effective social psychological interventions to promote behavior change in diverse domains” (Fisher et al., 2018, p. 59). With its holistic approach, the IMB model could therefore serve as a good theoretical basis for future research in an environmental sustainability context.

Yet, literature search revealed only one study that has previously tried to apply the IMB model to pro-environmental behavior: Using structural equation models (SEM), Seacat and Northrup (2010) demonstrated that the IMB model significantly predicts curbside

recycling behavior: participants scored moderately high on all predictors and accordingly high was the percentage of regularly recycled products. The research was however unable to confirm a direct path between recycling information and recycling motivation to curbside behavior. They concluded that even though both variables were important for predicting the target behavior, their effects were mediated by the level of recycling behavioral skills. This conclusion is in accordance with Fisher and Fisher's (1992) original paper which implies that when complex behavioral skills are less critical, information and motivation may have a direct effect on behavior. And the non-direct pathways appear "when a desired behavior is particularly complex or requires multiple behavioral skills to perform" (Seacat & Northrup, 2010; p. 400), which is the case for curbside recycling.

Previous research on household energy behavior change has investigated a similar topic but in a broader sense. In the Netherlands and Spain, Niamir et al. (2020) studied how behavioral, socioeconomic, and contextual factors impact investments such as in solar panels, house insulation, and energy-efficient appliances, conservation of energy, and switching to greener electricity sources. Corresponding to the IMB components *information* and *motivation*, their findings show that awareness about environmental and energy problems and personal and social norms play a crucial role in predicting sustainable household actions. In addition, people's income, education, gender, and structural dwelling factors seem to have an influence on energy decisions. People with a higher education or higher economic comfort in this study were more likely to make sustainable investments. Moreover, men had a greater likelihood of making investment decisions than women. With regards to dwelling factors, house owners and those owning larger residences were more likely to install solar panels at their houses. Despite some overlap with certain IMB model components, this study lacks more specific analysis of solar panel installation knowledge and motivation and insufficiently investigates people's behavioral skills as an important predictor of behavior.

Considering the apparent research gap in terms of knowledge, motivation, and behavioral skills with regard to solar panel adoption in particular, this study conducts elicitation research on basis of the IMB model in two different populations (Germany and Spain) whose solar market situations may generally enable citizens to make pro solar investment decisions (SolarPower Europe, 2020). Moreover, these countries have previously been collaborating in the promotion of renewable energies (Held et al., 2007). This way, an understanding of possible deficits in the three different determinants of behavior change in these populations will be gained which can then be used for the design of future interventions aimed at promoting solar panel installations for private households. Moreover, this study aims to expand literature by further testing the application of the IMB model in a sustainable behavior context. In order to examine the models' assumptions, rooftop solar panel installation-related behaviors are also measured. In addition, the study explores contextual and individual-level factors such as economic comfort, type of residence, gender and level of education which may facilitate or impede the intention to set up rooftop solar panels (Niamir et al., 2020). Variables are measured with a specifically developed questionnaire.

In line with the predictions of the IMB model (Fisher & Fisher, 1992) and initial findings of the model in the context of environmental sustainability (Seacat & Northrup, 2010), it is hypothesized that levels of information (i.e., knowledge; H1), motivation (H2), and behavioral skills (H3) are positively related to solar panel installation-related behaviors. Taking into account the complexity of solar panel installation behavior and that several behavioral skills are necessary for the target behavior, it is expected that a non-direct pathway emerges: knowledge and motivation will be positively related to behavioral skills and the effect of knowledge and motivation on behavior will be mediated by behavioral skills (H4.1 and H4.2). Finally, information and motivation are expected to be statistically dependent constructs (H5). To incorporate objective behavioral skills, it is also hypothesized that power

of co-decision and economic comfort are positively related to subjective behavioral skills (i.e., self-efficacy; H6). In addition, it is explored whether solar panel installation-related behaviors differ depending on individual level factors (level of education, gender, economic comfort, power of co-decision), and dwelling characteristics (cf. Niamir et al., 2020).

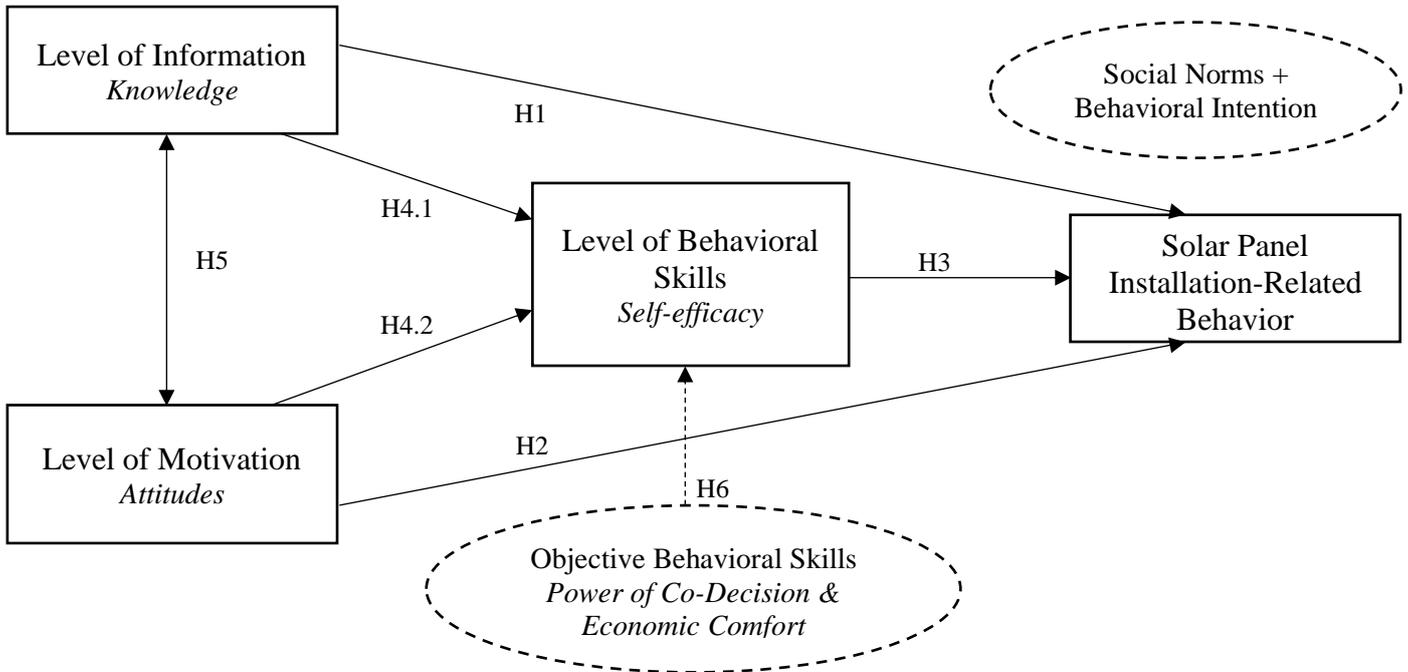


Figure 2: overview of variables and their hypothesized relations, with main measurements of constructs in italic. Control variables are displayed in circles. IMB model relations are displayed in solid lines and other hypothesized relations displayed in dotted lines.

Method

Participants

In advance of this study, an estimation of the sample size was done in line with Fritz and MacKinnon's (2007) guidelines for determining the sample size for conducting mediational studies suggesting a size of at least 126 for each country group (power = .80, using condition HM with $\alpha = .27$, $\beta = .45$ and percentile bootstrap test). Sizes of the α - β pathway were determined averaging the findings of four different studies (Amico et al., 2005; Misovich et al., 2003; Seacat & Northrup, 2010; Starace et al., 2006). Ethical approval by the ethics committee of Utrecht University was given up front (approval number: 22-0357).

Participants were approached via social media platforms, survey platforms (*SurveyCircle* and *Prolific*), email, and in person. Inclusion criteria involved having a residence in Germany or Spain and being at least 18 years old. Initially, another criterium for inclusion had been that participants needed to have power of co-decision in the building they live in, however due to a high drop-out rate and an interest in further investigating this variable as ‘objective behavioral skills’, participants with no power of co-decision were kept in the sample. People who had already invested in the installation of solar panels at home were excluded from the study, as were those failing at least one of the attention checks or not fully completing the survey. This led to a total sample size of 167 (Germany-based $n = 138$, Spain-based $n = 29$). Because of the low participation rate and resulting underpower of the Spain-based group, this sample could not be included in further analysis of the study.

The Germany-based sample consisted of 53.6% percent of women, 45.7% percent of men, and 0.7% preferred not to disclose, with an average age of 38 ($M = 38.28$, $SD = 15.09$, range: 18-81). The majority of respondents was employed (i.e., either full time, part time, or on temporary leave: 47.4%). 31.1 percent were students or apprentices, 10.6 percent were self-employed, 5.8 percent retired, 2.9 percent homemaker-housewife or -husband, and 2.2 percent unemployed or seeking for a job. The highest level of education achieved for the majority was a university degree with 36.2 percent having a bachelor’s degree, 26.1 percent having a master’s degree, and 1.4 percent having a PhD. The other 36.2 percent had a high school diploma which can be explained by the fact that several students were included in the sample and that doing an apprenticeship used to be very common in Germany (Bundesinstitut für Berufsbildung, 2019). Participation was voluntary and was not compensated for due to the survey’s short and simple nature. Only participants recruited via *SurveyCircle* were reimbursed with credit points and participants on *Prolific* received a compensation of about 2.30€.

Materials

An online questionnaire was created with the survey software *Qualtrics*. Variables were measured with a survey available in English, German and Spanish. The translations from the original English version to Spanish and German were done by natives who are also proficient in the English language. Understanding of both translated versions was tested with other natives and their feedback was incorporated accordingly.

Predictor Variable: Information

To capture the Information variable quantitatively, knowledge about the problem, also cited as “an individual’s store of [sustainable] behavior information” (Fisher et al., 2018; p.69), was assessed with a modified version of an existing knowledge scale (Niamir et al., 2020). The scale consisted of eleven items aimed at capturing knowledge/awareness about the problem of fossil fuel usage and benefits of solar energy (Appendix A). All items were scored on a continuous scale from zero to 100 using a visual slider. Marked endpoints with “totally disagree” reflecting zero and “totally agree” reflecting 100 were used. Consequently, a higher information score indicated more knowledge. Reliability analysis of the scale revealed good internal consistency (Cronbach’s $a = .88$). Item 7 to 10 aimed to measure people’s awareness about the consequences that their behavior, i.e., their energy decision, has on the environment. In a broader sense, knowledge about the problem in this case, means that people also need to be aware of the relation between the negative impact that a non-sustainable action such as using fossil fuels has on the environment. Therefore, it was also important to capture whether people know that climate change is not a random phenomenon but caused by human activity (item 1). And whether they are aware of the extent of environmental problems, what they entail in general (e.g., threat to human health and destabilization of nature), and the importance of environmental protection (item 2 to 6). In

addition, item 11 measured people's awareness about governmental support for the installation of solar panels such as subsidies, or low interest rates for loans which can be relevant incentives for people to engage in a pro-environmental target behavior (Maki et al., 2016). These types of financial incentives are provided in Germany (Van Noy, 2022), and several regions in Spain can benefit from them as well (e.g., the community of Madrid or the community of Catalonia; Lumisa, 2021).

Predictor Variable: Motivation

In order to identify motivational obstacles which may hinder people to act on their store of information, personal and social motivation to install solar panels were measured. In line with recent recommendations for quantitative elicitation research, attitudes and social norms were assessed (Fisher et al., 2018). Attitudes towards the installation of solar panels for private households were measured with a specifically designed scale asking into the overall attitude towards the installation of rooftop solar panels and five additional subitems. The six items showed good reliability (Cronbach's $a = .83$). Social norms were assessed with a modified version of an existing social norms scale (Niamir et al., 2020). Five items focused on whether the encouragement of different social groups (family, friends, colleagues, neighbors etc.) and their behavior would impact people's decision to install solar panels (Cronbach's $a = .91$). As for the *information* variable, items of both measurements were scored on a continuous scale with marked endpoints from zero to 100 using a visual slider, so that higher scores signified a more positive attitude and a higher relevance of social norms (for complete scales see Appendix B). Furthermore, a single item measured intention to engage in the target behavior under the condition that behavioral skills are provided: 'I would invest in rooftop solar panels at home, if more practical information on how I can invest in solar panels would be available'. Principal component analysis (PCA) revealed two

components, suggesting that social norms and behavioral intention had one common factor and attitudes another one. Therefore, the different scales could not be treated as one variable and attitudes were used as the main measure of motivation to test the IMB model.

Predictor Variable: Behavioral Skills

Assessment of subjective behavioral skills (Appendix C) was done by measuring self-efficacy (cf. Fisher et al., 2018). In line with Bandura's guide for constructing self-efficacy scales (2006) participants were asked how confident they feel they can initiate the process of installing solar panels at home (item 2). Because behavioral skills entail practical knowledge about how to act on the target behavior, people were also asked how confident they felt that they have the relevant practical information for rooftop solar panel installation (item 1). Again, items had to be answered on a scale from zero to 100 with marked endpoints using a visual slider. Thereby, a zero indicated that people were not confident at all and 100 that they were very confident. Reliability analysis showed acceptable internal consistency of these two items (Cronbach's $\alpha = .77$), and PCA extracted one component, therefore they were treated as one scale. Accordingly, a higher score represented a higher level of behavioral skills. It is furthermore noted to take objective behavioral skills into account (Fisher et al., 2018) which were partly controlled for by asking whether participants had power of co-decision in their building and by considering their economic comfort (Appendix D). Besides, rooftop types and solar radiation play an important role in the objective judgement of whether rooftop installation is feasible (SolarPower Europe, 2020), however, assessing that was beyond the scope of this study. (Note that power of co-decision and economic comfort served as control variables but also as predictors to investigate H6).

Outcome Variable: Solar Panel Installation-Related Behaviors

Solar-panel installation-related behaviors were measured with seven items asking into various sub-behaviors in the past five years that may suggest the initiation of a rooftop solar investment decision (Appendix E; Cronbach's $a = .88$). These different actions were determined based on steps that are commonly taken when planning a home solar electric system, for example, making financial calculations, checking the place's suitability for solar panels, or contacting possible companies that install solar panels (U.S. Department of Energy, n.d.). Whether these actions apply was indicated with binary answer options ('yes' or 'no', scored as one and zero respectively). A higher total score on this variable therefore implied being closer to engaging in the target behavior of power generation from solar panels at home.

Procedure

First, participants read an information letter before giving consent (Appendix F). Then, country of residence, age, gender, installation of solar panels were recorded. If the inclusion criteria were met, participants were asked about their employment status and power of co-decision. Moreover, contextual factors (residence type, residence size, tenure status) and other individual-level factors (economic comfort and level of education) were recorded. Next, participants were presented with the scales assessing knowledge, attitudes, social norms, behavioral skills, and finally behavioral intention in the mentioned order. For each scale they were asked to indicate their extent of agreement with the different statements that were presented to them (except for the two subjective behavioral skills items where they had to indicate their level of confidence). Below every statement was a visual bar that people were instructed to touch or click on for a slider to appear and for it to be moved. By having the slider invisible first, it was ensured that participants were not biased to move it in a

specific direction based on its previous location. Moving the slider to the very left was explained to be representative of ‘totally disagree’ and moving it to the very right of ‘totally agree’. In between the predictor scales were three attention checks hidden in which participants were instructed to either move the slider to the very left or very right. In the end, they were asked to answer ‘yes’ or ‘no’ to the different questions asking for people’s previous behavioral steps taken to possibly install solar panel.

Data Analysis

Data preparation involved computation of average scores of knowledge, attitude, social norms plus behavioral intention, and self-efficacy for all subjects which were used for further analysis. Moreover, the variable solar panel installation-related behavior was calculated by summing the seven behavior items. Checking of regression assumptions revealed a slightly non-normal distribution of all IMB variables in the model. Since the analysis program makes use of percentile bootstrapping (nonparametric) the violation of regression assumptions was however trivial (Hayes, 2022). Linearity was violated for only some IMB variables which might be explained by the fact that a part of the respondents scored zero on the outcome variable. Since not all variables were affected by the violation it was decided to still analyze the data based on multiple regression.

Levels of information, motivation, and behavioral skills and average scores of the different items were investigated using descriptives. The relationship of age, gender, level of education, economic comfort, power of co-decision, and residence size with solar panel installation-related behaviors, was analyzed using a Kruskal-Wallis Test. The relationship of residence type and tenure status with the outcome variable, was analyzed using a Mann Whitney U Test.

As it was not feasible to conduct a path analysis with structural equation modeling (SEM) within this project, two separate simple mediation analyses (Model 4) were conducted to test the IMB model assumptions using the *SPSS* extension *PROCESS* v4.0 by Andrew F. Hayes. A heteroscedasticity consistent standard error and covariance matrix estimator was used. First, with knowledge (quantitative) as predictor (X_1), self-efficacy as mediator (M) and installation-related behaviors (quantitative) as the outcome variable (Y) controlling for the motivation measure attitudes (X_2). Then, with attitudes (quantitative) as the main predictor (X_1), self-efficacy as mediator (M) and installation-related behaviors (quantitative) as the outcome variable (Y) this time controlling for knowledge (X_2). Since *PROCESS* is not able to distinguish between additional predictors part of the mediation model (X_2) and covariates simply added to be controlled for (C_x ; cf. Hayes, 2022), the two previously mentioned mediation models were constructed separately. This way the bootstrap confidence intervals (95%) of the indirect effects for both knowledge X_1 and motivation X_2 on behavior Y could be obtained. Both mediation models also included the following control variables: the combined measure of social norms and behavioral intention (C_1), objective behavioral skills: power of co-decision (C_2) and economic comfort (C_3). The relationship between knowledge and motivation was investigated by performing a non-parametric bivariate correlation.

Results

Elicitation Results

Average scores on the IMB constructs and items could range from zero to 100. Descriptive statistics indicate rather high average scores of knowledge ($M = 79.23$, $SD = 16.85$) as well as attitudes ($M = 79.26$, $SD = 16.67$) and behavioral intention ($M = 63.49$, $SD = 27.58$). On average people scored only moderately high on the social norms scale ($M = 44.10$, $SD = 27.553$) and self-efficacy ($M = 41.66$, $SD = 28.75$). The behavioral measure

revealed that people overall scored low on solar panel installation related behaviors ($M = 1.75$, $SD = 16.85$, [0-7]). Investigation of item average scores show lower scores on the knowledge items relating to economic benefits of environmental protection ($M = 64.77$, $SD = 26.64$) and fiscal support by the government ($M = 62.53$, $SD = 31.33$). Moreover, people scored lower on social norms items relating to social groups modeling the target behavior ($M = 50.97$, $SD = 33.95$; $M = 43.89$, $SD = 32.31$) than on items relating to social groups encouraging them ($M = 56.49$, $SD = 33.51$; $M = 47.25$, $SD = 31.51$). And family and friends items ($M = 56.49$, $SD = 33.51$; $M = 50.97$, $SD = 33.95$) were rated higher than other social groups items ($M = 47.25$, $SD = 31.51$; $M = 43.89$, $SD = 32.31$). See Appendix G for a complete overview of item descriptives.

Dwelling Characteristics and Individual-Level Factors

Exploratory analyses show that differences in dwelling characteristics such as the type of residence (house or apartment), size of the residence, as well as tenure status (renting or owning a residence) had an impact on solar panel installation-related behaviors. People living in a house were more likely to have taken steps to invest in solar panels than people living in an apartment ($U = 1570.50$, $p = .000$, $r = .31$). Similarly, people renting a residence were less likely to have taken steps to invest in solar panels than those owning the residence ($U = 1636.50$, $p = .001$, $r = .29$). Moreover, residence size significantly predicted behavior, as did level of education: People with residences between 151m² and 200m² and more had taken more steps than those with smaller residences ($H(4) = 11.27$, $p = .024$, $\eta^2 = .05$), and people with a higher level of education had taken more steps than those with a lower level of education ($H(3) = 12.31$, $p = .006$, $\eta^2 = .06$). Power of co-decision was also significantly related to the outcome variable: people who had power of co-decision were more likely to have taken steps to install solar panels than those that had no power of co-decision or were

unsure ($H(2) = 10.20, p = .006, \eta^2 = .05$). Age ($H(45) = 45.51, p = .451$), gender ($H(3) = 5.20, p = .074$), and economic comfort ($H(4) = 2.80, p = .592$) were unrelated to behavior.

IMB Model Relations

In the following results for the main model (i.e., IMB predictors and control variables: other motivation measure, power of co-decision, and economic comfort) are reported. See Table 1 for a complete overview of indirect and direct effects. Contrary to the predictions of the IMB model, mediation analyses revealed a non-significant direct effect of knowledge (H1) on behavior, ($b = -.03, t(132) = -1.28, p = .089$). The effect of attitudes on behavior was significant as predicted (H2; $b = .05, t(132) = 2.51, p = .021$). Moreover, self-efficacy (behavioral skills) did indeed reliably predict behavior (H3; $b = .03, t(132) = 4.48, p < .001$). Thereby, the objective behavioral skill measure economic comfort was unrelated to subjective behavioral skills ($b = .40, t(132) = .14, p = .859$), whereas the other objective behavioral skills measure power of co-decision had a significant negative association with subjective behavioral skills partly confirming H6 ($b = -11.03, t(132) = -4.45, p < .001$). This model explained 27% of variance in solar panel installation-related behaviors ($R^2 = 0.27$). Finally, no indirect pathways of knowledge and attitudes through self-efficacy emerged (H4.1, H4.2; $b = .00, SE = .01, 95\% \text{ bootstrap CI } [-.01; .02], b = .01, SE = .01, 95\% \text{ bootstrap CI } [-.01; .02]$).

Table 1*Indirect (through Behavioral Skills) and Direct Effects on Behavior*

	<i>Indirect effect</i>				<i>Direct Effect</i>			
	<i>b</i>	<i>SE</i>	95% CI		<i>b</i>	<i>SE</i>	95% CI	
			<i>Lower</i>	<i>Upper</i>			<i>Lower</i>	<i>Upper</i>
Knowledge (X ₁)	0.01	0.01	- 0.01	0.02	- 0.03	0.02	- 0.07	0.01
Attitude (X ₂)	0.01	0.01	- 0.01	0.02	0.05*	0.02	0.01	0.09
Self-Efficacy (M)					0.03***	0.01	0.02	0.04

Note. CI = confidence interval. Coefficients and confidence intervals of both mediation models are displayed with self-efficacy direct effects being the same.

* $p < .05$. ** $p < .01$. *** $p < .001$.

Bivariate correlations of the different IMB constructs (displayed in Table 2) show that the three motivation measures attitudes, social norms, and behavioral intention were all significantly positively associated with each other. In line with H5, information and motivation (i.e., knowledge and attitude) were statistically dependent constructs ($r = .66, p < .001$). Solar panel installation-related behaviors were associated with attitude ($r = .26, p < .001$) and self-efficacy ($r = .39, p < .001$).

Table 2*Correlations of IMB Measurements and Outcome Behavior in the Germany-Based Sample*

<i>Variable</i>	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>	<i>6</i>
1. Knowledge	1.00					
2. Attitude	0.66**	1.00				
3. Social Norms	0.17*	0.31**	1.00			
4. Behavioral Intention	0.04	0.22**	0.46**	1.00		
5. Self-Efficacy	0.15	0.13	- 0.07	0.02	1.00	
6. Behavior	0.14	0.26**	- 0.12	0.00	0.39**	1.00

Note. *M* indicates mean and *SD* indicates standard deviation. Spearman's rho coefficients are displayed.

* $p < .05$. ** $p < .01$.

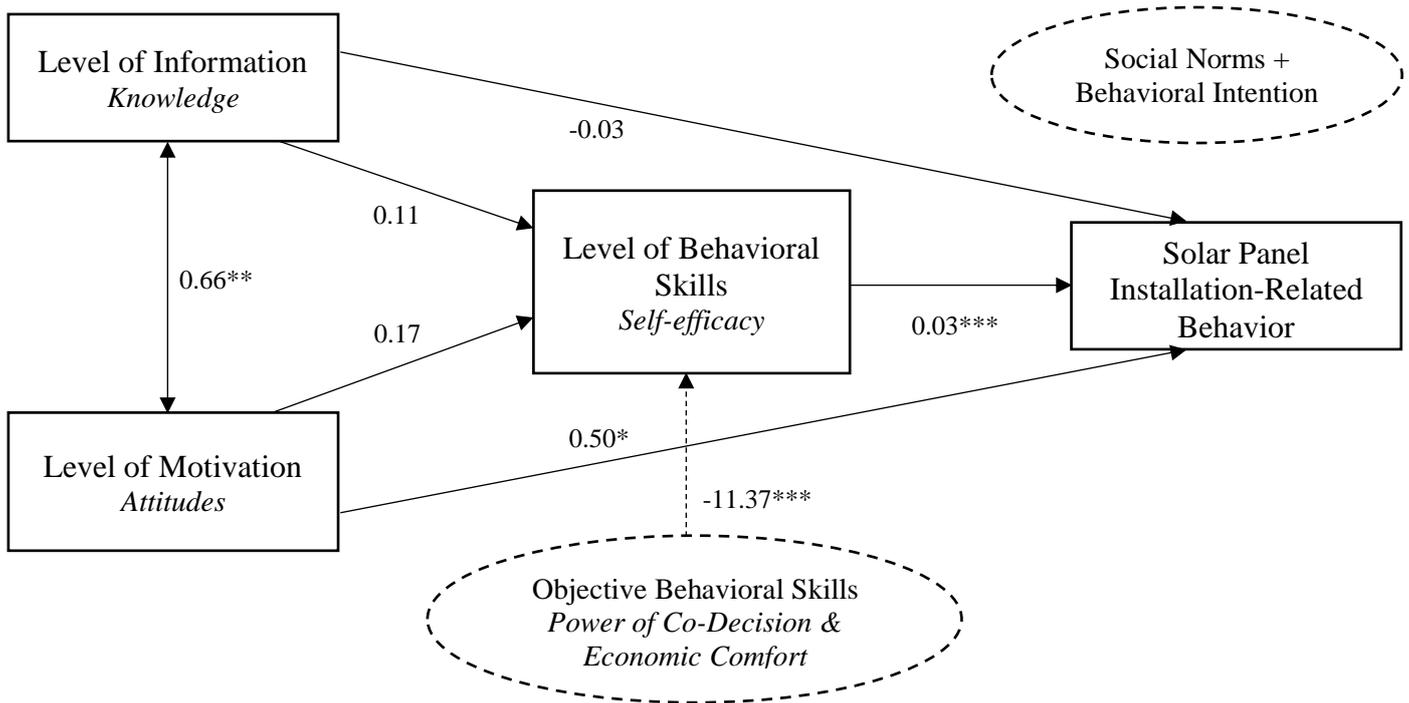


Figure 3: overview of variables and their detected relations, with main measurements of constructs in italic. Control variables are displayed in circles. IMB model relations are displayed in solid lines and other hypothesized relations displayed in dotted lines. b weights for each effect are shown. Note: for objective behavioral skills, only the effect of power of co-decision is shown.

* $p < .05$. ** $p < .01$. *** $p < .01$.

Discussion

The purpose of this study was to get insights into possible deficits in the three different determinants of behavior according to the IMB model: information, motivation, and behavioral skills with regards to rooftop solar panel installation for private households. The exploratory results of the Germany-based sample suggest that on average people seem to already have a lot of knowledge about the problem of fossil fuel usage, its impact on the environment, as well as the positive impact of generating solar energy. In comparison to the other items, people seemed to be less aware about the economic benefits of environmental protection and the existence of subsidies for the installation of solar panels (see Appendix G for average scores on the different items of all scales). Similarly high average scores on the attitude and behavioral intention measure suggest that people also seem to have a relatively

high personal motivation to install solar panels. In contrast, social motivation (i.e., the impact of social norms on the decision to install solar panels) seems to be only moderately important to people, whereby encouragement of social groups to engage in the target behavior appears to be more influential than the actual modeling of behavior by social groups. And friends and family may have greater power to encourage people than other social groups such as colleagues or neighbors. In other words, these elicitation results imply that there are only little deficits in information and motivation. Finally, a deficit in behavioral skills may be noted: average scores suggest that people feel only moderately confident that they are able to take the relevant steps to install solar panels at their home and that they have a moderately low confidence that they have the relevant practical information to engage in the target behavior. These feelings of self-efficacy were not affected by economic comfort but were significantly lower when people had no power of co-decision in their building. Taking objective behavioral skills into account (as recommended by Fisher et al., 2018) the obtained results confirm the hypothesis that objective behavioral skills have an impact on subjective behavioral skills (i.e., self-efficacy; H6), that is people with no power of co-decision or who are unsure about their power of co-decision also feel less efficacious.

Moreover, this study aimed to expand the literature by testing the application of the IMB model, which is already well established in a health context, further in a pro-environmental behavior context. Unlike the model's prediction, level of information was not related to solar panel installation-related behaviors (H1). However, research shows that in some cases when the target behavior is particularly complex, the direct pathways of information and motivation to behavior do not emerge (Amico et al., 2005; Seacat & Northrup, 2010). Since the behavior of installing solar panels involves various behavioral steps it may indeed be rather complex which may in turn explain this finding. On the other hand, the anticipated direct effect of motivation (attitudes) on behavior was significant (H2):

as people had a more positive attitude towards solar panels, they had also taken more steps to invest in solar panels. This is in line with the general predictions of the IMB model in a health context (Fisher & Fisher, 2002), but stands in contrast to the previously mentioned explanation and findings testing the IMB model in a curbside recycling context where attitudes did not predict behavior (Seacat & Northrup, 2010). In agreement with literature findings of a direct effect of behavioral skills on behavior (e.g., review by Fisher and Fisher, 2002), people with a higher level of behavioral skills (self-efficacy) had taken more steps to a solar panel investment decision (H3). Finally, unlike the model's predictions, the effect of information (H4.1) and motivation (H4.2) on behavior was not mediated by behavioral skills. Considering the complexity of the target behavior which makes the emergence of the indirect pathways more likely (Fisher & Fisher, 1992), as also substantiated by a previous application of the IMB model in another pro-environmental context (Seacat & Northrup, 2010), this finding was particularly unexpected. Therefore, it may be concluded that the IMB model applies only partly in the context of solar panel installation.

There are several factors that may have impacted the results: Regarding the elicitation findings (i.e., levels in information, motivation, and behavioral skills) the rather high scores may partly be as a result of social desirability bias. Since the information letter in the beginning of the survey also communicated that promoting the installation of solar panels is important to mitigate climate change, this may have positively influenced people in their attitudes but also their state of knowledge (e.g., being aware that energy source choice has an impact on the environment) and their behavioral intention. Additionally, at the time of the survey being launched the Ukraine war had just begun bringing about strong increases in energy prices and leading to an energy crisis in Germany which strongly relies on fossil fuels from Russia (Tollefson, 2022). This rise in fossil fuel prices has made renewable energy comparatively cheaper which may have encouraged people to acquire more information

about alternative energy sources such as solar energy. This may also have led to more positive attitudes towards solar panels for private households. In fact, that idea is supported by a professor of renewable energy systems (Prof. Dr.-Ing. Volker Quaschnig) who says that there has been a change in public opinion to more pro-renewable power (National Geographic, 2022). On top of that, Germany has advocated for an even quicker clean energy transition at that time (National Geographic, 2022). A recent study by Karaeva et al. (2022) has highlighted that the level of development of a country with regards to a certain energy source is related to public attitude towards that source. Considering Germany's current relatively well developed solar market and infrastructure (SolarPower Europe, 2020) and their future plans, this may have contributed to overall positive attitudes.

Furthermore, the IMB model relations found in this study should be interpreted with caution due to some methodological limitations. The information construct in the context of solar panel installation has only been captured partly: adapting an existing knowledge scale (Niamir et al., 2020), we focused more on knowledge about environmental problems, awareness about the consequences of the problematic behavior of fossil fuel usage and awareness about the benefits of solar energy. Ideally, this construct would holistically capture people's store of accurate and inaccurate information (for example heuristics) facilitating and impeding the target behavior respectively (Fisher et al., 2006). Measuring accurate information would have additionally included all information necessary for obtaining solar power from your own solar panels such as knowledge about what factors are crucial for performing that behavior (e.g., knowing that a certain solar radiation on your building is important). An improved measure should be developed in cooperation with experts on solar panel installation. In addition, future research should do focus groups or interviews with people not having solar panels at their home to identify common heuristics (e.g., I have a

medium income, so I cannot invest in solar panels) which may then be quantified in a questionnaire.

Apart from that, behavioral skills were measured in a rather general sense (people's self-efficacy to install solar panels, controlling for power of co-decision and economic comfort as objective behavioral skills). However, given that more expert knowledge on the topic would be available, self-efficacy and objective behavioral skills for a sequence of solar panel installation behaviors should be incorporated in the measure. For example, in an IMB study about HIV prevention, Fisher and Fisher (2002) assessed objective as well as perceived abilities for a sequence of behaviors (purchasing and putting on condoms, negotiation of consistent condom use before or during sexual contact, negotiation of HIV testing and monogamy, etc.). Besides, the current study focused on people who have no solar panels installed at their homes yet, since they are the target group of interest for identifying deficits in the IMB components and developing potential behavior change campaigns. But that also means that it was only possible to capture some behavioral steps people had already taken as a measure of behavior. Since in literature the IMB components predict the actual target behavior (i.e., solar power generation at home) one might argue that the outcome variable was not accurately assessed. Hence, capturing the information and behavioral skills constructs as well as the target behavior variable more thoroughly may ultimately lead to different IMB model relations in the same context. Finally, differences as a result of mediation analysis based on multiple regression (MR) models instead of structural equation modeling (SEM) which is commonly used to test the IMB model and yields more benefits (Ramli et al., 2018), should be taken into account.

Nevertheless, this study provides some critical insights and practical implications. The elicitation results demonstrate a deficit in behavioral skills to obtain solar power from solar panels in private households in Germany. This also explained the small number of steps

people had taken so installing solar panels. This information can serve as a crucial insight for behavior change campaigns to focus on making people feel more efficacious to engage in the target behavior. The strong relation of people's power of co-decision with their perceived ability to install solar panels, as well as the relation of tenure status (renting/owning) with their behavioral steps taken, highlight the importance of involving landlords of buildings with several dwelling units and other relevant stakeholders such as investors. A first step would certainly be to convince these stakeholders of the relevance to start investing in sustainable changes to their building, so that a second step could be to inform tenants that there are options for sustainable changes to their building. This way also people not owning a residence will be able to generate solar power at their building. Especially given the current energy prices and the study's initial findings of an overall good knowledge and positive attitudes towards solar panel installation, this situation provides a big opportunity to tackle behavioral skills and mobilize information and motivation to promote the installation of solar panels for private households. To further enhance people's knowledge and motivation this study suggests that people should be more informed about fiscal support by the government. And that campaigns making use of social norms should take into account that people were more willing to install solar panels when encouraged by ingroup members rather than when they model the target behavior.

Conclusion

This study is the first to investigate the determinants of solar panel installation for private households using the IMB model. Not only does this contribute to research by partly demonstrating the applicability of a health behavior model in a new context, but also expands literature on individual energy-related choices and behavioral factors that may affect them. Moreover, this study highlights the importance of elicitation research before developing a

behavioral intervention: Although not all model relations could be confirmed, a deficit in behavioral skills and relatively high levels of information and motivation provide guidance on how to further promote solar panel installation. Future research should re-test the model in the same context with improved measures of the information and behavioral skills constructs, and outcome variable to obtain more reliable relationships of the IMB model. In a follow-up step, elicitation research in other countries that have a well-developed market for solar panels such as Spain or the Netherlands is recommended. Other subgroups of interest for extending this research could be stakeholders owning large building complexes and the private sector.

References

- Amico, K. R., Toro-Alfonso, J., & Fisher, J. D. (2005). An empirical test of the information, motivation and behavioral skills model of antiretroviral therapy adherence. *AIDS Care, 17*(6), 661-673. <https://doi.org/10.1080/09540120500038058>
- Bamberg, S., & Möser, G. (2007). Twenty years after Hines, Hungerford, and Tomera: A new meta-analysis of psycho-social determinants of pro-environmental behaviour. *Journal of Environmental Psychology, 27*(1), 14-25. <https://doi.org/10.1016/j.jenvp.2006.12.002>
- Bandura, A. (2006). Guide for constructing self-efficacy scales. In *Self-Efficacy Beliefs in Adolescents* (pp. 307-337). Information Age Publishing.
- Bundesinstitut für Berufsbildung. (2019). *Datenreport / D1 Indikatoren zur Berufsbildung in Europa*. <https://www.bibb.de/datenreport/de/2019/101742.php>
- Clayton, S., Litchfield, C., & Geller, E. S. (2013). Psychological science, conservation, and environmental sustainability. *Frontiers in Ecology and the Environment, 11*(7), 377-382. <https://doi.org/10.1890/120351>
- Creutzig, F., Roy, J., Lamb, W. F., Azevedo, I. M., Bruine de Bruin, W., Dalkmann, H., Edelenbosch, O. Y., Geels, F. W., Grubler, A., Hepburn, C., Hertwich, E. G., Khosla, R., Mattauch, L., Minx, J. C., Ramakrishnan, A., Rao, N. D., Steinberger, J. K., Tavoni, M., Ürge-Vorsatz, D., ... Weber, E. U. (2018). Towards demand-side solutions for mitigating climate change. *Nature Climate Change, 8*(4), 260-263. <https://doi.org/10.1038/s41558-018-0121-1>
- Ehret, P. J., Hodges, H. E., Kuehl, C., Brick, C., Mueller, S., & Anderson, S. E. (2021). Systematic review of household water conservation interventions using the information–motivation–behavioral skills model. *Environment and Behavior, 53*(5), 485-519. <https://doi.org/10.1177/0013916519896868>

- Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, intention and behavior: An introduction to theory and research*. Addison-Wesley.
- Fisher, J. D., & Fisher, W. A. (1992). Changing AIDS-risk behavior. *Psychological Bulletin*, *111*(3), 455-474. <https://doi.org/10.1037/0033-2909.111.3.455>
- Fisher, J. D., & Fisher, W. A. (2002). The information-motivation-behavioral skills model. In R. J. DiClemente, R. A. Crosby, & M. C. Kegler (Eds.), *Emerging theories in health promotion practice and research: Strategies for improving public health* (1st ed., pp. 40-70). San Francisco, CA: John Wiley & Sons.
- Fisher, W. A., & Aberizk, J. D. (2018). Elicitation research. In H. Blanton, L. J. M., & W. G. D. (Eds.), *Measurement in social psychology* (1st ed., pp. 56-74). Taylor & Francis Group. <https://doi.org/10.4324/9780429452925>
- Fisher, W. A., Fisher, J. D., & Harman, J. (2009). The information-motivation-behavioral skills model: A general social psychological approach to understanding and promoting health behavior. *Social Psychological Foundations of Health and Illness*, 82-106. <https://doi.org/10.1002/9780470753552.ch4>
- Fisher, W. A., Fisher, J. D., & Shuper, P. A. (2014). Social psychology and the fight against AIDS: An Information-Motivation-Behavioral Skills model for the prediction and promotion of health behavior change. *Advances in Experimental Social Psychology*, *50*, 105–193. <https://doi.org/10.1016/B978-0-12-800284-1.00003-5>
- Fritz, M. S., & MacKinnon, D. P. (2007). Required sample size to detect the mediated effect. *Psychological Science*, *18*(3), 233-239. <https://doi.org/10.1111/j.1467-9280.2007.01882.x>
- Hayes, A. F. (2022). *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach* (3rd ed.). New York, NY: The Guilford Press.

- Held, A., Ragwitz, M., Huber, C., Resch, G., Faber, T., & Vertin, K. (2007). *Feed-in systems in Germany, Spain and Slovenia: A Comparison*.
<http://www.mresearch.com/pdfs/docket4185/NG11/doc44.pdf>
- Hertwich, E. G., & Peters, G. P. (2009). Carbon footprint of nations: A global, trade-linked analysis. *Environmental Science & Technology*, *43*(16), 6414-6420.
<https://doi.org/10.1021/es803496a>
- International Renewable Energy Agency. (2019). *Renewable energy and jobs – Annual review 2020*. Abu Dhabi, United Arab Emirates: International Renewable Energy Agency (IRENA). https://www.irena.org//media/Files/IRENA/Agency/Publication/2020/Sep/IRENA_RE_Jobs_2020.pdf
- Karaeva, A., Magaril, E., Torretta, V., Viotti, P., & Rada, E. C. (2022). Public attitude towards nuclear and renewable energy as a factor of their development in a circular economy frame: Two case studies. *Sustainability*, *14*(3), 1283.
<https://doi.org/10.3390/su14031283>
- Kracher, A. (2021). *Renewable energy communities Exploring behavioral and motivational factors behind the willingness to participate in renewable energy communities in Germany* (Master's thesis, Lund University, Lund, Sweden).
<https://lup.lub.lu.se/luur/download?>
- Lumisa. (2021, July 22). *¿Cuáles son las subvenciones para placas solares en 2021?*.
<https://www.lumisa.es/post/107/en/what-are-the-subsidies-for-solar-panels-in-2021>
- Maki, A., Burns, R. J., Ha, L., & Rothman, A. J. (2016). Paying people to protect the environment: A meta-analysis of financial incentive interventions to promote proenvironmental behaviors. *Journal of Environmental Psychology*, *47*, 242-255.
<https://doi.org/10.1016/j.jenvp.2016.07.006>

- Masson-Delmotte, V., Zhai, P., Pirani, A., Connors, S., Péan, C., Berger, S., & Caud, N. (2021). *Climate change 2021: The physical science basis : Summary for policymakers*. <https://www.ipcc.ch/report/ar6/wg1/>
- Misovich, S. J., Martinez, T., Fisher, J. D., Bryan, A., & Catapano, N. (2003). Predicting breast self-examination: A test of the information-motivation-behavioral skills model. *Journal of Applied Social Psychology, 33*(4), 775-790. <https://doi.org/10.1111/j.1559-1816.2003.tb01924.x>
- National Geographic. (2022, May 6). *How the Ukraine war is accelerating Germany's renewable energy transition*. <https://www.nationalgeographic.com/environment/article/how-the-ukraine-war-is-accelerating-germanys-renewable-energy-transition>
- Niamir, L., Ivanova, O., Filatova, T., Voinov, A., & Bressers, H. (2020). Demand-side solutions for climate mitigation: Bottom-up drivers of household energy behavior change in The Netherlands and Spain. *Energy Research & Social Science, 62*, 101356. <https://doi.org/10.1016/j.erss.2019.101356>
- Oreskes, N. (2004). The scientific consensus on climate change. *Science, 306*(5702), 1686. <https://doi.org/10.1126/science.1103618>
- Ramli, N. A., Latan, H., & Nartea, G. V. (2018). Why should PLS-SEM be used rather than regression? Evidence from the capital structure perspective. *Partial Least Squares Structural Equation Modeling, 171-209*. https://doi.org/10.1007/978-3-319-71691-6_6
- Ritchie, H., & Roser, M. (2020). *Energy*. Our World in Data. <https://ourworldindata.org/energy>
- Ritchie, H., & Roser, M. (2020). *Energy*. Our World in Data. <https://ourworldindata.org/com-and-other-greenhouse-gas-emissions>

- Seacat, J. D., & Northrup, D. (2010). An information–motivation–behavioral skills assessment of curbside recycling behavior. *Journal of Environmental Psychology, 30*(4), 393-401. <https://doi.org/10.1016/j.jenvp.2010.02.002>
- SolarPower Europe (2020): *EU Market Outlook for Solar Power 2020-2024*. <https://www.gensed.org/assets/attachments/dosyalar/EU-Market-Outlook-2020-2024-SolarPowerEurope.pdf>
- Starace, F., Massa, A., Amico, K. R., & Fisher, J. D. (2006). Adherence to antiretroviral therapy: An empirical test of the information-motivation-behavioral skills model. *Health Psychology, 25*(2), 153-162. <https://doi.org/10.1037/0278-6133.25.2.153>
- Tollefson, J. (2022). What the war in Ukraine means for energy, climate and food. *Nature, 604*(7905), 232-233. <https://doi.org/10.1038/d41586-022-00969-9>
- United Nations. (2015). *Paris Agreement*. Retrieved from United Nations website: https://unfccc.int/sites/default/files/english_paris_agreement.pdf
- U.S. Department of Energy. (n.d.). *Planning a home solar electric system*. <https://www.energy.gov/energysaver/planning-home-solar-electric-system>
- Van Noy, Y. (2022, March 25). *KfW Förderung Photovoltaik in 2022: Die Übersicht*. Retrieved January 13, 2022, from https://www.enpal.de/magazin/kfw-foerderung-photovoltaik?utm_source=Search%20Ads&utm_campaign=11206227548&utm_term=128897337506&utm_content=562384766620&utm_placement=&utm_device=c&utm_keyword=&utm_adposition=&gclid=Cj0KCQjwg_iTBhDrARIsAD3Ib5i-kp_7rUWpiOhKQbiSyUX1hms6BdZzo7Di238LjK-P3dlXipIpMMkaAtfsEALw_wcB

Appendix A

Knowledge Questionnaire Items

Knowledge

Climate Change Involvement Knowledge

I know that...

... climate change is caused by human activity.

Environmental Problems Awareness

I am aware that...

...environmental issues, even in one region, affect other regions.

...environmental issues like climate change is caused by our use of fossil fuels (e.g., coal, oil, gas).

...when I use fossil fuels (coal, oil, gas) there are greenhouse gasses emitted which threaten human health.

...protecting the environment is a means of stimulating economic growth.

...nature is fragile and if we don't take care of it properly, it could destabilize.

Energy Decision Awareness

I am aware that...

...I can help solve environmental, climate, and energy problems.

...my energy source choice (renewables or fossil fuels) has an impact on the environment.

...avoiding fossil fuels use will help solve wider environmental issues.

...the installation of solar panels has a positive impact on the environment.

Governmental Support Awareness

...the installation of solar panels for private households is predominantly financially supported by the government (e.g., by subsidies, i.e., financial grants, or low interest rates for loans)

all items were measured with a scale from zero to 100 with marked endpoints using a visual slider (0 = 'totally disagree', 100 = 'totally agree')

Appendix B

Motivation Questionnaire Items

Motivation

Attitudes

Overall I have a positive attitude towards the installation of rooftop solar panels for private households.

Overall I have a negative attitude towards the installation of rooftop solar panels for private household.

Solar power is a good power generation strategy because it creates zero emissions.

Promoting the deployment of solar and the installation of solar panels can create new jobs.

Installing solar panels can help solve environmental, climate, and energy problems.

Households should not be the ones investing in solar panels.

Installing solar panels for power generation at home is a cost-effective investment.

Social Norms

I would invest in the installation of solar panels at home if...

...my friends and family encouraged me to do so.

...my friends and family would also invest in solar panels.

... social groups or associations I am part of (e.g., sports team, colleagues, neighbors, hobby groups etc.) encouraged me to do so.

... social groups or associations I am part of (e.g., sports team, colleagues, neighbors, hobby groups etc.) would also invest in solar panels.

... I got public labels which my neighbors can see

Behavioral Intention

I would invest in rooftop solar panels at home, if more practical information on how I can invest in solar panels would be available.

all items were measured with a scale from zero to 100 with marked endpoints using a visual slider (0 = 'totally disagree', 100 = 'totally agree')

Appendix C

Behavioral Skills Questionnaire Items

Behavioral skills

*Behavioral skills knowledge**

How confident do you feel that you have the relevant practical information for rooftop solar panel installation in private households?

*Self-efficacy**

How confident do you feel that you can take the relevant steps to install solar panels at home?

* all items were measured with a scale from zero to 100 with marked endpoints using a visual slider (0 = 'not confident at all', 100 = 'very confident')

Appendix D

Contextual and Individual-Level Factors Items

Contextual Factors (Dwelling Characteristics)

Type of Residence

What type of residence do you currently live in?

Apartment/flat, house

Tenure Status

What is your current tenure status?

I/My flat-/housemates own the residence, I/My flat-/housemates rent the residence

Size of Residence

How big is your residence approximately?

Less than 50 m², 50-100 m², 101-150 m², 151-200 m², more than 200 m²

Individual-Level Factors & Objective Behavioral Skills Measures

Education

What is your highest level of education?

high school diploma , bachelor, master, doctorate

Economic Comfort

Which of the following descriptions is closest to how you feel about living on your household's income nowadays?

Finding it very difficult to live in current income, finding it difficult to live in current income, coping on current outcome, living comfortably on current income, living very comfortably on current income

Power of Co-Decision

Do you have power of co-decision in your building? (i.e., do you have a say in decisions such as whether changes should be made in your building)

yes, not sure, no

Appendix E

Solar Panel Installation-Related Behaviors Questionnaire Items

Behavior*

*Initiation of Installation Investment Decision***

In the past five years have you...

... tried to find out whether your household would be financially able to invest in rooftop solar panels at home?

... calculated potential costs and savings of installing rooftop solar panels at your home?

... assessed whether your home is suitable for installing solar panels (e.g., getting suitability of roof checked or evaluation of shading)?

...obtained information about the estimated system size of a potential solar panel installation for your home?

... obtained information about your households electricity needs to help determine the size of a potential solar installation for your home?

... informed yourself about possible companies that install rooftop solar panels?

... contacted possible companies that install rooftop solar panels?

* Total scores ranging from 0 to 7

** Binary answer options: 'yes' (coded = 1) or 'no' (coded = 0)

Appendix F

Informed Consent

Information Letter

Behavior change factors of solar panel installation

Welcome to this study,

Through this letter I would like to ask your permission to participate in my research about behavior change determinants of solar panels adoption.

The study is conducted as part of my Master thesis of the “Social, Health, and Organizational Psychology” program under supervision of a teacher at Utrecht University.

The purpose of this online questionnaire study, is to gain insight into people’s knowledge, motivation, and behavioral skills with regards to installing rooftop solar panels in households. Each participant will be asked to answer some questions about their knowledge, motivation, and behavioral skills to install solar panels at home. Also, you will be asked about your solar panel installation behaviors. For each task element, you will receive a more detailed explanation of what is asked from you later on.

Collecting these information aims to help designing future interventions aimed at promoting the installation of solar panels which is important in order to mitigate climate change.

Therefore, by taking part in this study you can make an important contribution to behavior change and sustainability research.

The study will take approximately 10 minutes to complete. Participation in this study is voluntary and will not be compensated for. You can discontinue the questionnaire at any time, without giving a reason and without any adverse consequences for you.

All collected data and personal information will be anonymously processed. This means that later on the results cannot be traced back to you. The consequence of this is that you cannot be informed about your personal results after the study has been completed. However, I could inform you about the results of the study as a whole. If you wish to be informed about the results of this study, then please let me know via email (h.kuhlmann@students.uu.nl). Your data will be stored for at least 10 years. This is according to the appropriate VSNU guidelines. You can read more information about privacy on the website of the Personal Data Authority: <https://autoriteitpersoonsgegevens.nl/nl/onderwerpen/avg-europese-privacywetgeving>

If you have questions or comments about the study, you can contact the program coordinator Esther Kluwer (e.s.kluwer@uu.nl). If you have an official complaint about the investigation, you can send an e-mail to the complaints officer via klachtenfunctionaris-fetsocwet@uu.nl (contact details data protection officer: <https://www.uu.nl/organisatie/praktische-zaken/privacy/functionaris-voor-gegevensbescherming>)

If you indicate that you want to participate in this study, you will be asked to sign an informed consent form. By signing this form, you indicate that you are sufficiently informed about the study, that you want to participate in the study, and that you voluntarily do so.

Kind regards,
Hannah Kuhlmann

Consent Form

For participation in a study for the program Social, Health, and Organizational Psychology

Behavior change factors of solar panel installation

I hereby confirm that:

- I was satisfactorily informed about the study, and I have read and understood the written information on the study.
- I was informed that the current study is conducted by a masters student as part of their master thesis.
- I have had the opportunity to ask questions regarding the study and my questions have been answered satisfactorily.
- I was allowed sufficient time to consider whether to give my consent.
- I participate of my own free will.

I understand that:

- I have the right to withdraw my consent at any time without having to give a reason and that withdrawing my participation has no further consequences.
- My information will be processed anonymously.
- The outcomes of the study cannot be considered as a diagnostic test.
- I will not be informed about my individual results
- I hereby consent to participate in the study referred to above.

Yes, I consent

No, I do not want to participate

Appendix G

Average Item Scores Germany

Knowledge items average scores

Item	<i>M</i>	<i>SD</i>	Minimum	Maximum
I know that climate change is caused by human activity.	85.69	23.66	2.00	100.00
I am aware that environmental issues, even in one region affect other regions.	89.60	18.29	3.00	100.00
I am aware that environmental issues like climate change are mainly caused by our use of fossil fuels (coal, oil, gas).	79.41	24.96	3.00	100.00
I am aware that when I use fossil fuels (coal, oil, gas) there are greenhouse gasses emitted which threaten human health.	85.83	20.94	3.00	100.00
I am aware that protecting the environment is a means of stimulating economic growth.	64.77	26.64	0.00	100.00
I am aware that nature is fragile and if we don't take care of it properly, it could destabilize.	89.83	18.73	3.00	100.00
I am aware that I can help solve environmental, climate and energy problems.	77.32	25.73	0.00	100.00
I am aware that my energy source choice (renewables or fossil fuels) has an impact on the environment.	82.91	23.49	2.00	100.00
I am aware that avoiding fossil fuels use will help solving wider environmental issues.	72.76	27.87	0.00	100.00
I am aware that the installation of solar panel has a positive impact on the environment.	80.88	23.07	3.00	100.00
I am aware that the installation of solar panels in private households is predominantly financially supported by the government (e.g., by subsidies, i.e., financial grants, or low interest rates for loans).	62.53	31.33	0.00	100.00

Motivation items average scores

Latent Variable	Item	<i>M</i>	<i>SD</i>	Minimum	Maximum
Attitude	Overall, I have a positive attitude towards the installation of rooftop solar panels for private households.	87.68	18.43	0.00	100.00
	Solar power is a good power generation strategy because it creates zero emissions.	81.82	23.30	0.00	100.00
	Promoting the deployment of solar and the installation of solar panels can create new jobs.	76.63	22.98	0.00	100.00
	Installing solar panels can help solve environmental, climate, and energy problems.	81.50	23.33	0.00	100.00
	Households should be investing in solar panels.	79.07	23.50	0.00	100.00
	Installing solar panels for power generation at home is a cost-effective investment.	68.87	23.77	0.00	100.00
Social Norms	I would invest in the installation of solar panels at home if my friends and family encouraged me to do so.	56.49	33.51	0.00	100.00
	I would invest in the installation of solar panels if my friends and family would also invest in solar panels.	50.97	33.95	0.00	100.00
	I would invest in the installation of solar panels at home if social groups or association (e.g., colleagues, neighbors, sports teams, hobby groups etc.) encouraged me to do so.	47.25	31.51	0.00	100.00
	I would invest in the installation of solar panels if social groups or association (e.g., colleagues, neighbors, sports teams, hobby groups etc.) would also invest in solar panels.	43.89	32.31	0.00	100.00
	I would invest in solar panels if I got public labels which my neighbors can see.	21.91	27.89	0.00	100.00

Behavioral Intention	I would invest in the installation of solar panels at home if I had more practical information on how I can invest in solar panels would be available.	62.48	27.58	0.00	100.00
----------------------	--	-------	-------	------	--------

Self-efficacy items average scores

Item	<i>M</i>	<i>SD</i>	Minimum	Maximum
How confident do you feel that you have the relevant practical information for rooftop solar panel installation at home?	37.86	30.24	0.00	100.00
How confident do you feel that you can take the relevant steps to install solar panels at your home?	45.46	34.03	0.00	100.00