

Beauty and the budget: homeowners' motives for adopting solar panels in a post-grid parity world

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Abstract

Buildings account for 32% of global final energy use and are a major contributor to greenhouse gas emissions. Therefore, the transition to renewable energy supply of buildings, especially distributed solar power, is a key element of climate change mitigation. As the policy landscape is shifting and financial incentives for renewables are increasingly phased out, a nuanced understanding of homeowners' intention to install solar panels is key for reaching a broad market appeal. By analyzing a dataset of 408 Swiss homeowners' stated preferences in the context of building retrofits, this paper identifies two key segments of likely solar adopters, including a premium segment featuring higher willingness to pay for coloured and building integrated solar modules, and a value segment with more price-sensitive customers. Differences between likely adopters and likely non-adopters, as well as between two distinct segments of likely adopters, are investigated along sociodemographic, psychographic and social aspects. Our analysis shows that aesthetic aspects of solar panels are key for expanding the customer base, and that likely adopters are more likely to be surrounded by neighbors, friends and relatives who have already installed solar panels than likely non adopters. The results also reveal that the premium segment cares more about aesthetic aspects in general purchasing decisions and shows higher ecological concern than the value segment.

Keywords

Solar panels, residential solar energy, consumer segmentation, choice experiment, building integrated photovoltaics, peer effects

Highlights

- We investigate determinants of homeowners' intention to install solar panels.
- Aesthetic aspects of solar panels matter for expanding the customer base.
- Adopters are more likely to have peers who opted for solar than non adopters.
- We profile two segments of future solar adopters: a value and a premium one.
- The latter cares more about aesthetic aspects in general purchasing decisions.

1. Introduction

International climate policy goals require a massive decarbonization of the energy system. Buildings account for 32% of global final energy use and are a major contributor to greenhouse gas emissions (Lucon et al., 2014 [1]). Therefore, the transition to renewable energy supply of buildings is a key element of climate change mitigation. Among building-related renewable energy solutions, distributed solar energy has experienced a dynamic growth (IEA, 2017 [2]) and is an area of investment particularly appealing to households, whose importance in the solar energy investor landscape has grown over the last ten years (Bergek et al., 2013 [3]; Karneyeva & Wüstenhagen, 2017 [4]). In light of this, accelerating the deployment of solar panels in existing residential dwellings is a promising decarbonization strategy. Moving beyond the niche of the “dark green” segment (that is intrinsically motivated mainly out of ecological reasons), or innovators and early adopters (that generally tend to immediately adopt disruptive technologies), and reaching the “early majority” or “light green” customers (Rogers, 1995 [5]; Wüstenhagen et al., 2003 [6]; Villiger et al., 2000 [7]) in the residential solar sector, however, will crucially depend on the ability to meet, adapt and anticipate households’ needs and preferences. Such an enhanced understanding of consumer preferences will be even more crucial in light of the fact that financial incentives for renewables are more and more being phased out in several countries (Karneyeva & Wüstenhagen, 2017 [4]).

The contribution of this paper to the existing research is threefold.

First, there is a large body of empirical work investigating the drivers of solar panels in the residential sector, which takes a retrospective approach, with actual adopters as the main object of investigation (see for instance: Dharshing, 2017 [8]; Balta-Ozkan et al., 2015 [9]; Briguglio & Formosa, 2017 [10]; Sigrin et al., 2015 [11]). However, there is still a scarcity of forward-looking studies that provide insights into the next generation of promising customer segments in a changing solar market. We contribute to closing this research gap by identifying potential future solar adopters and investigating what distinguishes them from likely non-adopters. Such a forward-looking approach is relevant for policy makers and practitioners alike: identifying potential adopters based on past adoption is like driving a car by looking into the rearview mirror. This may lead to a biased perspective on the drivers of future developments: yesterday’s adopter profile is likely to be different from tomorrow’s, in the same way later adopters differ significantly from earlier ones (Sigrin et al., 2015 [11]). In fact, only a few studies have taken such a forward-looking approach (Hille et al., 2018 [12]; Curtius et al., 2017 [13]; Scarpa and Willis, 2010 [14]; Faires et al., 2006).

Second, we characterize two different segments of potential solar adopters, distinguishing between (a) those homeowners ready to opt (and pay) for a premium solution, and (b) a more price-sensitive value segment. More precisely, we investigate the intention to install not a generically defined solar panels' solution, but rather two carefully described roof-top solar panels options, which are consistent with current industry trends. To the best of our knowledge, this contribution is the first one to distinguish premium solar customers from more price-sensitive ones, following an approach to consumer segmentation that has been already applied in the field of green power adoption (Tabi et al., 2014 [16]).

Third, we profile the different consumer segments according to individuals' socio-demographic features (e.g. gender, age), psychographic traits (e.g. values and attitudes) and behaviour of their social reference group. We contribute to the literature on environmental behaviour by looking at relatively unexplored drivers of (future) solar adoption: among psychographic factors, along with environmental attitude and technical affinity, centrality of visual product aesthetics (Bloch et al., 2003 [17]) is investigated; concerning social aspects, our stated preference approach allows to enlarge the scope beyond the impact of installed solar panels in the neighborhood on homeowners' intention to adopt, and investigate the role of friends' and family members' choices in this context.

The remainder of this paper is structured as follows. Section 2 presents the related literature; Section 3 presents material and methods; results are presented and discussed in Section 4. Finally, Section 5 concludes by providing marketing and policy recommendations, and presents limitations and ideas for further research.

2. Related literature

This study relates to the literature dedicated to the diffusion of solar technology in the residential sector. Existing research has identified several adoption drivers, which, following the common distinction introduced by Rogers (1995) [5], can be grouped into characteristics of the product (discussed in section 2.1) and characteristics of the adopter (discussed in section 2.2).

2.1 Product characteristics

Purely financial factors influencing residential solar adoption include: the expected return on investment (see for instance, Dharshing, 2017 [8]; Karneyeva and Wüstenhagen, 2017 [4]) and its determinants, such as financial incentives (Simpson & Clifton, 2017 [18]; Karneyeva & Wüstenhagen, 2017 [4]) and solar irradiation (Schaffer & Brun, 2015 [19]; Rode & Weber, 2016 [20]); upfront investment costs (Scarpa & Willis, 2010 [14]; Hille et al., 2018 [12]; Islam, 2014 [21]); and energy cost savings (Islam, 2014 [21]; Hille et al., 2018 [12]). For later adopters financial aspects seem to be more important than for early adopters (Simpson & Clifton, 2017 [18]), but in light of recent cost reductions for solar, financial factors may no longer represent the key diffusion driver, especially for households (Karneyeva & Wüstenhagen, 2017 [4]). Moreover, surveys show that homeowners have steep implicit discount rates and rarely calculate the rate of return when it comes to building-related energy investments (Ebers & Wüstenhagen, 2015 [22]).

Non-financial factors play an equally important role in solar energy uptake in the domestic sector. The aesthetic aspects of solar panels matter for adoption according to Faiers and Neame (2006) [15] who, based on interviews and a survey conducted in the UK, show that, for the ‘early majority’, perceived poor visual appearance discourages adoption. More insight on the role of visual attractiveness is offered by Hille et al. (2018) [12], who show that the provision of colored panels similar to the colors common on tiled roofs (i.e. red or black), significantly impact the likelihood of choosing solar. The same study also documents higher willingness to pay for building integrated panels (BIPV) than building attached ones (BAPV)¹, consistent with the finding of a questionnaire carried out in Australia by Hampton and Eckermann (2013) [24]. Country of origin of the panels is also an aspect that influences the Swiss homeowners’ preferences with regard to solar panels’ adoption, according to Hille et al. (2018) [12].

2.2 Adopter characteristics

Adopter characteristics include sociodemographic features, psychographic traits (also referred as personality traits, these include values and behavioral attitudes) and exposure to the choices made within the social reference group (which is known for spurring “peer effects”, whereby an individual’s adoption decision is influenced by the choices of her social reference group, as it will be discussed in this Section further below).

¹ BIPV is understood as an integral building component: the electricity producing modules are here both a functional unit of the finished building and a construction element of the building skin, since they replace conventional materials (Heinstein et al. 2013 [23]). Building Attached Photovoltaics (BAPV), instead, describes the additive installation of a PV system to an already finished building envelope (Heinstein et al. 2013 [23]).

Although the results are not always consistent, a number of sociodemographic predictors for residential solar uptake have been identified in the literature. While a set of studies find a positive relationship between household income and solar adoption (Dharshing, 2017 [8]; Sigrin et al., 2015 [11]; Rode and Weber, 2016 [20]), others show that its impact is weakly negative in incentive-intensive periods (Simpson & Clifton, 2017 [18]) or even insignificant (Balta-Ozkan et al., 2015 [9]; Simpson & Clifton, 2017 [18] as far as late adopters are concerned). Accumulated savings are more relevant than income according to Balta-Ozkan et al. (2015) [9].

The impact of age is also not conclusive: results show negative (Islam, 2014 [21]; Briguglio & Formosa, 2017 [10]), insignificant (Graziano & Gillingham, 2014 [25]) or non-linear relationships (Dharshing, 2017 [8]) between age and solar adoption.

Education is positively related to solar panels installation according to a number of studies (Dharshing, 2017 [8]; Balta-Ozkan et al., 2015 [9]; Sardianou & Genoudi, 2013 [27]; Sigrin et al., 2015 [11]); however, the result seems not to hold true when considering late adopters, as convincingly shown by Simpson & Clifton (2017) [18], or in some geographical contexts (Briguglio & Formosa, 2017 [10]). Education about solar energy (i.e. informed understanding of the costs and benefits of the technology) promotes the continued adoption according to Simpson & Clifton (2017) [18].

Concerning the impact of gender, which is less studied, Leenheer et al. (2011) [26] argue that women have a lower intention to generate their own energy, while Sardianou & Genoudi (2013) [27] conclude that gender does not affect the willingness to adopt renewable energies. The presence of children in the house favors solar adoption according to Sigrin et al. (2015) [11].

A review of the literature also shows mixed evidence on the impact of living in a single-house: while living in a detached (single) houses increases the likelihood of adoption compared to apartments in Switzerland (Baranzini et al., 2017 [28]) and terraced homes in the UK (Balta-Ozkan et al., 2015 [9]), this is not the case in Germany (Dharshing, 2017 [8]) and Malta (Briguglio & Formosa, 2017 [10]).

As far as psychographic drivers are concerned, environmental attitude/concern is arguably the most widely investigated. For instance, Chen (2014) [29] concludes that environmental values are the most important factor for solar power system installation intention. In addition to that, Baranzini et al. (2017) [28] find that the percentage of green voters have a positive and highly significant impact on the adoption of solar panels in a municipality. However, other studies find that environmental friendly attitude may not necessarily translate into solar panels adoption (Schaffer & Brun, 2015 [19]; Schelly, 2014 [30]; Dharshing, 2017 [8]). The apparent

contradictory findings may be reconciled by the work by Simpson & Clifton (2017) [18] and Sigrin et al. (2015) [11], who argue that, while environmental aspects of solar are significant for ‘early adopters’, and even prioritized to financial components, this not the case anymore for later ones.

As far as other attitudinal factors are concerned, a group of studies deal with customer’s technical affinity. Two studies are worth mentioning. First, an interview-based study by Shelly (2014) reveals that interest and competence in technical innovation, as well as comfort with and enjoyment of technical information motivates solar adoption. Second, Leerneer et al. (2011) show, based on a consumer survey among about 2000 Dutch households, that affinity with technology positively affects a household's intention to generate its own power.

Turning to social aspects, a thriving strand of literature specifically focuses on the positive impact of existing nearby installations on adoption decisions, commonly referred as “geographical peer-effects” in solar or solar photovoltaic diffusion.

More specifically, several studies (Bollinger & Gillingham, 2012 [31]; Dharshing, 2017 [8]; Balta-Ozkan et al., 2015 [9]; Schaffer & Brun, 2015 [19]) conclude that, even controlling for spatially correlated preferences, policy and contextual factors, an additional solar installation in an area significantly increases likelihood of adoption of solar panels in the neighbourhood (so called “installed based effect”). Graziano and Gillingham (2014) [25] demonstrate that the effects diminish with distance and over time.

The role played by reference groups different from neighbours (such as friends and family) is, to the best of our knowledge, not thoroughly investigated in the literature, which focuses mostly on geographical contagion. Some results, however, point to their importance in driving adoption: Scarpa and Willis (2010) [14] found that the joint recommendation by a friend and a plumber significantly increases the willingness to pay for a renewable micro-generation system; Jager (2006) [32] observes that people who knew more owners of solar systems perceived the bureaucratic procedures connected with installation as less of a barrier; Sigrin et al. (2015) [11] reports that one of the most common events prompting solar adoption was talking to friends or family members who have first-hand experience with solar.

Other contributions explore the micro-foundations of peer-effects. They suggest that both merely observing nearby solar panels (“passive peer effects” or image motivation) and talking to neighbours about their decision to go solar (“active peer effects” or word of mouth) explain the installed based effect, as such activities either disclose information on the performance of solar systems and hence increase confidence in the technology (social learning), or activate the need to “keep up with the Joneses” and conform to the community (imitation

instinct/peers' pressure). More specifically, Rai and Robison (2013) [33], using data collected in 2011 through a survey of over 300 Texan solar panels' residential owners, show that solar adopters' reported decision period is a function of active and passive peer effects; Baranzini et al. (2017) [28] argue that both learning and imitation are important components of social contagion in the Swiss residential solar sector. Further, Brudermann et al. (2013) [34] shows that installation of solar panels among Austrian farmers is motivated by the need to foster the sense of adherence to a community, and Curtius et al. (2017) [13] finds that homeowners are prompted to install solar by the social pressure to comply with others' behavior (i.e. by an injunctive norm).

From a methodological point of view, it is worth pointing out that most of the empirical works investigating the characteristics of solar panels' adopters in the residential sector take a retrospective approach, with past adopters as the main object of investigation. To the best of our knowledge, few studies apply a forward-looking approach and provide insight on the next generation of solar customers. Among these, Hille et al. (2018) [12] and Curtius et al. (2017) [13] are based on the same survey dataset as the present study and adopt the same strategy to identify the target sample. Older studies have adopted different target group's identification strategies. Scarpa and Willis (2010) [14] studied the preferences of future residential adopters of renewable microgeneration systems in general, without focusing explicitly on solar energy, and work on a representative sample of households across England, Wales and Scotland; Faires et al. (2006) identified likely future adopters of solar as adopters of other residential energy efficiency measures who have not adopted solar energy yet.

3. Material and Methods

3.1 Target sample

The population of interest for this study are potential residential solar panels' adopters.

Switzerland, one of Europe's fastest growing solar markets (IEA, 2017 [35]) where there is already a good customer base for residential solar (25% of investors in solar energy in Switzerland, as of 2015, were residential consumers according to Karneyeva & Wüstenhagen, 2017 [4]), was chosen as area of study. Swiss prospective solar adopters were defined as owners of a residential pitched-roof² building (either a single-family house or a multi-family house with up to five apartments³), who intend to renovate their roof within the next 10 years and

² Owners of flat-roof buildings (9% of the screened-in respondents) were excluded as flat roofs are not entirely fit for a BIPV installation (Hille et al., 2018 [12]).

³ Owners of larger buildings were excluded as these are typically subject to a different investment decision process, involving group decision making, which would be difficult to compare with individual decision-making.

co-decide upon building retrofitting measures. In fact, installing solar panels in the context of a roof renovation is an ideal time because then the panels will be up for a long time; also, building retrofit is one of the identified trigger situations for solar adoption according to Sigrin et al. (2015) [11]. As solar capacity in Switzerland has been growing exponentially since the implementation of feed-in tariffs in March 2008 (KEV Stiftung, 2017 [36]), it is fair to say that the target group coincides with the early majority.

The sample consisted of 408 subjects, who are hence representative for the population of potential roof-renovators in Switzerland within a 10-year time horizon. The sample is identical with the one described in Hille et al. (2018) [12] and used by Curtius et al. (2017) [13]: a detailed description of the sampling procedure and overview of the sample can be found there⁴. While sharing the same dataset, the present paper differentiates from the above mentioned contributions, in that it explores the heterogeneity across different customer segments.

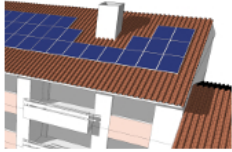
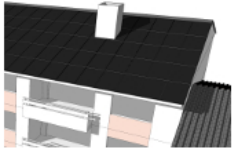
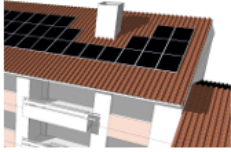
3.2 Survey structure

Sampled subjects participated in a survey administered in 2016. The survey was structured in different sections. First, respondents were asked to fill in a series of filter questions, to confirm that they match the predefined criteria. The survey then continued with an adaptive choice based conjoint (ACBC) section. This part was used to elicit preferences for selected attributes of the roof renovation solution. The ACBC section was set up in such a way that respondents were first asked in a so-called screening section whether they would consider opting for a series of different roof renovation projects which were described by a set of different financial and non-financial criteria, including (1) roof type, (2) color of the solar panels /roof, (3) origin of the PV panels, (4) investment costs, (5) revenues from electricity sales / reduction in electricity costs over 20 years and (6) purchase premium. A detailed description of the attributes and corresponding attribute levels can be found in Hille et al. (2018) [12]. In this screening section, respondents were not required to take a final choice between the presented options, but only to indicate whether they considered the presented options as “possibilities”.

⁴ Our dataset of potential roof renovators additionally overlaps with the dataset of 410 roof renovators analyzed in a recent paper by Curtius et al. (2017) [13]. Both datasets include only respondents who owned at least one residential building (single family home or apartment building with ≤ 5 units), planning to renovate their roof within 10 years and could co-decide upon renovation decision. Curtius et al. (2017) [13] additionally excluded those respondents that already have opted for a solar panels in the past, whereas this paper does not apply such a filter criterion given that potential future solar adoption does not exclude past adoption. Additionally, the dataset used in this paper excludes those respondents that owned a flat-roof dwelling given that flat roofs are not entirely fit for a BIPV installation (Hille et al., 2018 [12]), whereas Curtius et al. (2017) [13] did not apply such a filter criterion.

Responses were screened in order to identify whether respondents applied any knock-out criteria (e.g., by always excluding an option that contained a specific attribute level). Subsequently, respondents received a series of choice tasks containing three roof renovation options at the same time, where respondents were asked to take a final choice (see Figure 1 for an example of a choice task). Those options excluded product concepts defined as unacceptable during the previous screening section (Johnson and Orme, 2007 [37]).

Figure 1. Example of a choice task⁵

			
Roof type	Rack-mounted PV	Building-integrated PV	Rack-mounted PV
Color of the PV plant resp. of the roof	Blue	Black	Black
Origin of PV panels	Switzerland	Switzerland	Switzerland
Investment costs	40'000CHF	50'000CHF	45'000CHF
Revenues from electricity sales / reduction in electricity costs over 20 years	-40'000CHF	-40'000CHF	-20'000CHF
Purchase premium			
			

After the ACBC section, the survey continued with a wide range of psychographic questions. Based on the literature section (Section 2), a selection of psychographic questions were considered in the context of this study. This part consisted of a set of Likert-type statements: for each statement, respondents had to indicate to what extent they agree with it, using the widely-used 5-point Likert scale ranging from 1=“not agree at all” to 5= “totally agree”. Such statements were used to create multi-item scales related to respondent’s environmental attitude, centrality of visual product aesthetics⁶, opinion on the visual appeal of solar panels, and technical affinity. Existing scales available from the literature were used where possible. Scales were generated to increase reliability compared to single statements (Cooper et al., 2006 [38]) and were tested for internal consistency using Cronbach’s alpha. Values for each scale were obtained by averaging over the corresponding items. Table 1 provides details and descriptive statistics.

⁵ Translated; original in German and French.

⁶ Centrality of visual product aesthetics (henceforth product aesthetics centrality) is defined as the level of significance that visual aesthetics hold for a particular consumer in his/her relationship with products (Bloch et al., 2003) [17].

Table 1. Respondents' psychographic features: operationalization and descriptive statistics

Variable	Items	Source	Cronbach's alpha	Mean	Median	Standard deviation
Product aesthetics centrality	- Owning products that have superior designs makes me feel good about myself. - I enjoy seeing displays of products that have superior designs. - Beautiful product designs make our world a better place to live. - A product's design is a source of pleasure for me. - I am willing to spend more money on aesthetically beautiful objects	Bloch et al. 2003 [17]; own (translated from German)	0.9	3.5	3.6	0.8
Opinion on visual appeal of solar panels	-Usually, I like roofs with solar panels. -Most of the time, solar panels on roofs are unaesthetic*. -Solar panels are well suited to the exterior appearance of a building. -Solar panels have a negative influence on the appearance of a building*.	Own (translated from German)	0.9	3.5	3.5	0.9
Technical affinity	- I inquire about technical devices, even if I have no intention of buying. - I love owning new technical devices. - I find it easy to learn how to use an electronic device. - When it comes to technical devices, I know my stuff.	Adapted from Karrer et al. (2009) [39]	0.8	3.4	3.5	0.9
Environmental attitude	- Humans have the right to modify their natural environment to suit their needs*. - The balance of nature is strong enough to cope with the impacts of modern industrial nations*.	Adapted from Dunlap et al. (2000) [40]; Own (translated)	0.9	4.1	4.1	0.7

- Despite our special abilities humans are still subject to the laws of nature.
- I am convinced that the world's climate is changing.
- Climate change is caused mainly by humans and to a small extent by natural processes.
- The importance of climate change is exaggerated*.
- There is a lot of scaremongering in the climate change debate*.

* Reverse scale.

The survey then included closed-format questions to collect data on the respondent's socio-demographic characteristics. Those socio-demographic characteristics that were chosen for the purpose of this paper based on the literature review are further described in Table 2.

Table 2. Respondents' sociodemographic features: operationalization and descriptive statistics

Variable	Questions and answer options	Mean or Share in %	Standard Deviation
Income class	Respondents were asked to choose among five income classes (1 = Below 4880 CHF; 2 = 4880-7173 CHF; 3 = 7174-9702 CHF; 4 = 9703 – 13170 CHF; 5 = Above 13170 CHF).	3.3	1.2
Accumulated savings	Respondents were asked whether they are capable to make an investment worth 50'000 CHF without resorting to a loan.	63% (yes)	
Education	Respondents were asked whether they hold a university degree.	41% (yes)	

Education about solar energy	Respondents were asked whether manufacturing solar panels requires more energy than they ever produce in their lifetime ⁷ .	44% (correct answer)	
Age	Respondents were asked how old they are (in years).	50.7	13.9
Gender	Respondent were asked what their gender is.	60% (male)	
Children in the house	Respondents were asked to indicate the number of underaged people living in their house.	1.6	1.1
Ownership of a single house	Respondents were asked whether they lived in single-house or not.	80% (yes)	

Finally, we measured individuals' exposure to the choices of their social reference groups in two different ways in the survey (Table 3). First, we included categorical questions related to the respondent's reference groups' (perceived) behavior with respect to installation of solar panels. More precisely, respondents were asked about the amount of neighbors, friends and family members who have already adopted solar. Second, we investigated possible mechanisms behind possible social contagion effects by (a) asking whether the respondents had talked (in person or online) to people who have installed solar panels about their experience and (b) by exploring the respondents' perceived importance of peers' expectations in their decision to install solar (i.e. injunctive social norm).

Table 3. Respondents' exposure to the behavior of their social reference groups: operationalization and descriptive statistics

Variable	Questions and answer options	Mean or Share in %	Standard Deviation
Amount of neighbors who already adopted solar panels	Respondents were asked whether none (1), a minority (2), about half (3), a majority (4) or all (5) of their neighbors have already adopted solar panels. In addition, an "I do not know" answer option was provided which	1.8	0.6

⁷ Photovoltaic (PV) cells have an approximate energy payback time of one to three years. With a lifetime of at least 30 years, solar PV cells thus are capable of producing at least ten times as much electricity over the course of their lifetime than what is required to manufacture them (Ebers and Wüstenhagen, 2015 [22]).

	was coded as a missing value.		
Amount of friends who already adopted solar panels	Identical to question and answer options above	1.8	0.6
Amount of family members who already adopted solar panels	Identical to question and answer options above	1.5	0.7
Peers' pressure for installing solar panels	Respondents were asked to rate their agreement to the statement "I think that most of my acquaintances expect me to install solar panels" on a Likert scale ranging from 1 = completely disagree to 5 = completely agree.	2.4	1.1
Inquiry about solar panels	Respondents were asked whether they have talked to people who have already installed solar panels about their experience (in person or online)	51% (yes)	

3.3 Customer segmentation and profiling

Data collected from the ACBC were used as input for a hierarchical Bayesian (HB) analysis. This approach is used in order to estimate part-worth utilities separately for each individual (Software, 2009 [41]). Part-worth utilities are measures of relative desirability of a characteristic of a product; the higher the utility, the higher the positive impact one characteristic has on influencing people to opt for a certain product (Orme, 2010). In comparison to Hille et al. (2018) [12], who analyzed the available dataset for the overall sample, the present study goes one step further by segmenting the overall sample into different groups. This segmentation is done by applying a market simulation that converts part-worth utility data into respondents' choices for one of three different preselected building retrofitting solutions. In other words, we define three competing product options differing on certain product aspects and assign respondents to the product option with the highest purchase probability. This approach is known as "first choice" model or "maximum utility rule", as in such model

respondents are assumed to opt for the product option from a set of competing product options that provides them with the highest overall utility, as determined by summing the part-worth utilities associated with each product option characteristic (Sawtooth Software, 2005 [42]). This particular segmentation approach differs from other segmentation approaches such as cluster analysis or latent class, an approach that captures market heterogeneity by discovering segments of respondents who tend to have similar preferences based on their choice data (Sawtooth Software, 2015 [44]). Such a latent class approach has been used e.g. by Tabi et al. (2013) [16] for segmenting potential green electricity consumers as well as Islam (2014) [21] for segmenting potential solar adopters.

For our analysis, we identify three building retrofitting solutions, which are likely to be available in the next 10 years. Each option is described along the product features that were found to be relevant for adoption in existing research discussed in the literature section (Section 2). More specifically, we assume a premium solar option featuring colored and building integrated solar modules, a standard lower-priced solar option and a standard roof option without any solar installation. Table 4 provides a detailed overview of the three roof renovation options considered in the study. More precisely, the standard solar option features black rack-mounted panels; this decision is justified by the fact that black or dark bluish modules are the most widespread and predominant solution available on the market for rooftop solar systems (Heinstein et al., 2013 [23]). The premium solar panels solution, in contrast, comprises of red solar tiles, which are building-integrated elements resembling standard tiles in colour but able to generate power. Red integrated solar panel systems are considered very promising for the Swiss residential market (Heinstein et al., 2013 [23], Hille et al., 2018 [12]). It is further assumed that such an innovative solution enters the market with a premium, equal to 25% more compared to the incumbent standard solar panels solution (50'000 CHF versus 40'000 CHF).

The standard red roof option with no solar panels, instead, is assumed to cost much less (10'000 CHF) compared to any solar-energy-enriched solution but does not lead to any revenue from electricity sales or any reduction in electricity costs over the next 20 years (which is set at 20'000 CHF for the two solar options). As far as the origin of the solar panels is concerned, we assume that solar panels are manufactured in China, as it is today: in 2016, eight of the top ten module suppliers in the solar industry, who collectively had over 50% market share, were Chinese companies (PVtech, 2017 [45]).

After designing the competing options, we then applied the “first choice” model to create the customer segmentation. For instance, when the sum of one respondent’s part-worth utilities of each characteristic of option 1 (i.e., building-integrated panels, red solar panels, solar panels produced in China, etc.) is higher than the sum of the part-worth utilities of option 2 and 3, we assume that this particular respondent would opt for option 1.

Table 4. Roof renovation options considered in the study to create a customer segmentation

	Premium solar panels	Standard solar panels	Standard roof (No solar panels)
Roof type	building- integrated solar panels	building- attached solar panels	No solar panels
Color of the solar panels/ roof	Red	Black	Red
Origin of the solar panels	China	China	Not applicable
Investment cost (in CHF)	50'000	40'000	10'000
Revenues from electricity sales/ reduction in electricity costs over 20 years (CHF)	20'000	20'000	0

Once customer segments were identified via the above described market simulation, we then profiled the different segments and look for any significant difference with regard to sociodemographic, psychographic and social indicators (chosen based on the literature review) using non parametric statistical difference tests. We applied Mann Whitney U-tests for interval, ordinal and ratio variables, whereas Chi squared tests were applied for categorical variables. On the one hand, we contrast likely solar adopters (those preferring either the premium or the value solar option) with likely non-adopters (those who prefer a roof without solar panels); on the other hand, we compared potential premium solar adopters to the more price-sensitive value segment.

4. Results and discussion

4.1 Profiling likely adopters vs. likely non-adopters

Our segmentation reveals a wide difference in tastes with regard to solar panels' installation in the context of the next roof renovation. A large share (almost 45%) of the respondents would not install solar at all, given the assumptions on available options described in Section 3.3. To better understand what prompts future adoption of solar panels, we explore differences in sociodemographic, psychographic and social indicators between households willing to install solar in the course of their next roof retrofit project (likely adopters) and those who are not (likely non-adopters). Table 5 provides an overview of such differences.

Table 5. Profiling likely adopters vs. likely non-adopters in terms of sociodemographic, psychographic and social indicators

Variable	Mean or share (Adopters segments)	Mean or share (Non-adopters segment)	P-value (2-tailed)	
Income class (5 classes)	3.3	3.3	0.62	
Accumulated savings (% yes)	69%	55%	<.001	***
Education (% university degree)	43%	37%	0.18	
Education about solar energy (% correct answer)	46%	42%	0.38	
Age (years)	51.2	49.9	0.49	
Gender (% male)	68%	48%	<.001	***
Children in the house (n.)	1.6	1.5	0.27	
Ownership of a single house (% yes)	80%	79%	0.81	
Product aesthetics centrality (5=highest importance; 1=lowest importance)	3.5	3.5	0.61	
Opinion on visual appeal of solar panels (5=totally agree on solar panels being visually appealing; 1=not agree at all on solar panels being visually appealing)	3.6	3.4	0.02	**
Technical affinity (5=highest tech. affinity 1=lowest tech. affinity)	3.4	3.3	0.06	*
Environmental attitude (5=highest env.attitude 1=lowest env.attitude)	4	4.1	0.51	
Amount of neighbors who already adopted solar panels (5=all; 1=none)	1.8	1.6	<.001	***
Amount of friends who already adopted solar panels (5=all; 1=none)	1.7	1.5	<.001	***
Amount of family members who already adopted solar panels (5=all; 1=none)	1.5	1.3	0.01	***

Peers' pressure for installing solar panels (5=highest pressure; 1=lowest pressure)	2.6	2.1	<.001	***
Inquiry about solar panels (% yes)	53%	48%	0.32	
N	234	174		
Projected market share in CH	57%	43%		

*** Significant at the 1% level ** Significant at the 5% level * Significant at the 10% level

Interestingly, our results show that likely future adopters and likely non-adopters do not differ regarding income or education. This finding is consistent with recent studies on late adopters by Sigrin et al. (2015) [11] and Simpson and Clifton (2017) [18]. Similarly, respondents' age was not a good predictor of the likelihood to adopt solar panels in the foreseeable future, a fact that resonates with the non-conclusive evidence on the relationship between age and adoption rate found in former research. Instead, we found that women are less likely to opt for solar when undertaking a roof retrofit ($p = <.01$). The finding that gender has an impact on adoption likelihood is a rather novel result and calls for specific policy and marketing actions. A possible explanation could be connected to Leenheer et al. (2011)'s [26] finding that women have a lower intention to generate their own energy.

Furthermore, non-adopters are more likely to be capital constrained: respondents' ability to invest 50'000 CHF without asking for a loan is a good predictor of the willingness to install solar panels. This is consistent with Balta-Ozkan et al. (2015) [9]'s finding that adoption rate is influenced by wealth rather than income. Note that 63% of our respondents would have the capacity to readily invest 50'000 CHF without taking on a loan by a bank or private lenders. Moreover, the findings reveal that those homeowners living in a single house are on average not more likely to opt for solar energy compared to those who live in a multi-flat building. Furthermore, the number of underage people in the house does not significantly differ between likely adopters and non-adopters.

Surprisingly, our survey data reveal that education about solar energy does not affect intention to opt for solar panels: the share of respondents that hold misbeliefs related to the fact that manufacturing solar panels requires more energy than they ever produce in their lifetime is approximately the same in the likely adopters as in the likely non-adopter group. This finding is not completely unprecedented in the literature: Hampton and Eckerman (2013) [24], in fact, found that the perception that solar panels are environmentally worthwhile was not a predictor of the intention to purchase solar. To sum up, sociodemographic characteristics seem not to be very powerful when it comes to the purpose of profiling potential future solar consumers. This is why we turn to

psychographic variables, which according to several authors (e.g. Straughan and Roberts, 1999 [46]; Tabi et al., 2013 [16]) play a more significant role in profiling green consumers.

In this respect, our analysis shows that environmental attitude is not significantly different between those who display strong preferences towards adopting solar panels and those who do not. This is consistent with previous studies (e.g. Simpson and Clifton, 2017 [18]; Sigrin et al., 2015 [11]) who argue that later adopters are installing solar not strictly for environmental reasons. Moreover, likely adopters tend to have, on average, more competence and interest in technical innovation compared to likely non adopters, although this result is significant only at the 10% level.

Moreover, we show that aesthetic aspects do matter: those homeowners who prefer to opt for a roof renovation project without installing solar panels are also those who think that solar panels on roofs are not visually appealing and have a negative influence on the appearance of a building ($p = <.05$). This confirms Faiers and Neame (2006)'s [15] finding that the visual attractiveness of solar panels is key for adoption in the later phases of diffusion of the solar. Thus, investing in improving the aesthetic aspects of the technology appears to be a promising strategy when it comes to increasing adoption rates.

Turning to social indicators, our results are consistent with the existence of peer effects in the decision to adopt solar panels. The (perceived) share of neighbors who already installed solar panels is significantly higher for likely adopters than likely non adopters ($p = <.01$). This finding is consistent with the recent literature on spatial spillovers in the diffusion of solar (Bollinger & Gillingham, 2012 [31]; Dharshing, 2017 [8]; Balta-Ozkan et al., 2015 [9]; Schaffer & Brun, 2015 [19]). Furthermore, we show that likely adopters have a higher share of friends and relatives who have already installed solar panels than likely non-adopters ($p = <.01$). This result is in line with the observation that one the most common factors prompting solar adoption is talking to friends or family members about solar (Sigrin et al., 2015 [11]). Therefore, the present study suggests that not just neighbors, but also friends and family are influential in getting people to opt for solar energy.

Moreover, we try to disentangle between the main mechanisms through which peers' choices impact the likelihood to opt for solar. First, likely adopters more strongly believe that most of their acquaintances expect them to install solar panels compared to the likely non-adopters ($p = <.01$). We infer from this result that believing that installing solar panels is the "right thing to do" (i.e. a commonly approved behavior by a person's

social reference group) significantly increases homeowners' intention to adopt solar energy. This result supports the findings by Curtius et al. (2017) [13], who argue that homeowners are prompted to install solar by the social pressure to comply with others' behavior. On the contrary, having talked (in person or online) to people who have already opted for solar about their experience in the adoption process does not seem to significantly influence likelihood for adoption. To sum up the results, passively observing neighbors, friends or family members adopting solar panels and believing that going solar is "the right thing to do" seem to be more effective in getting households to install solar panels than to encourage exchange between potential adopters and past adopters.

4.1 Profiling premium segment vs. value segment

Our segmentation reveals that, under the scenario as described in Table 4, 26% of the respondents would constitute the premium segment featuring higher willingness to pay for coloured and building integrated solar modules, whereas 31% would constitute the value segment with more price-sensitive customers. Hence, as a next step, we explore differences between homeowners willing to adopt a standard lower-priced solar option (value segment) and those who are willing to go for a premium solution (premium segment) (Table 6).

Table 6. Profiling the premium vs. value segment in terms of sociodemographic, psychographic and social indicators

Variable	Mean share (Value Adopters segment)	or Mean share (Premium Adopters segment)	P-value (2-tailed)	
Income class (5 classes)	3.3	3.3	0.79	
Accumulated savings (% yes)	67%	71%	0.52	
Education (% university degree)	39%	49%	0.15	
Education about solar energy (% correct answer)	43%	50%	0.25	
Age (years)	50.2	52.5	0.27	
Gender (% male)	70%	66%	45%	
Children in the house (n.)	1.7	1.6	0.61	
Ownership of a single house (% yes)	82%	78%	0.45	
Product aesthetics centrality (5=highest importance; 1=lowest importance)	3.4	3.6	0.04	***
Opinion on visual appeal of solar panels (5=totally agree on solar panels being visually appealing; 1=not agree at all on solar panels being visually appealing)	3.6	3.6	0.26	
Technical affinity (5=highest tech. affinity 1=lowest tech. affinity)	3.4	3.4	0.73	
Environmental attitude (5=highest env.attitude 1=lowest env.attitude)	4	4.1	0.1	*
Amount of neighbors who already adopted solar panels (5=all; 1=none)	1.8	1.8	0.8	
Amount of friends who already adopted solar panels (5=all; 1=none)	1.7	1.7	0.71	
Amount of family members who already adopted solar panels (5=all; 1=none)	1.5	1.5	0.99	
Peers'pressure for installing solar panels (5=highest pressure; 1=lowest pressure)	2.5	2.6	0.6	
Inquiry about solar panels (% yes)	50%	50%	0.77	
N	128	106		
Projected market share in CH	31%	26%		

*** significant at the 1% level ** significant at the 5% level * significant at the 10% level

As explained in Section 3.3, a value segment's likely adopter is defined as one homeowner who obtains an

utility from choosing a standard solar product (black building-attached solar panels, costing 40 000 CHF) higher than not installing any solar panels as well as higher than opting for a more expensive premium solar option (red building integrated panels, costing 25% more than the standard ones), on her/his newly renovated roof. Note that, as there is no previous literature which compares groups of likely solar adopters with different willingness to pay and different preferences for the product's features, we have no priors on the dimensions that could discriminate between our two likely adopters' segments. Therefore we compare the two likely adopters' segment along the same dimensions used to compared likely adopters and not adopters.

Our analysis shows that sociodemographic factors did not play any significant role in explaining the difference between the two segments of likely solar adopters. In contrast, our results suggest that psychographic aspects have higher explanatory power when it comes to understanding segment affiliation. More precisely, the premium segment tends to care to a significant higher extent about aesthetic aspects in their general product purchasing decisions ($p = <.05$). This finding is certainly plausible given that a BIPV system often resembles conventional roofs in terms of used color and shape and thus contributes to an improved visual appearance of the overall building. Hence, BIPV - even when priced at a premium compared to conventional rack-mounted solar panel solutions - would appeal to people that care a lot about the visual appeal of products.

Furthermore, we also find the premium segment to report stronger environmental motives compared to the value segment, albeit only significant at the 10% level. In other words, the above-average willingness to pay for a premium solar product is still likely to come from environmentally more oriented people.

5. Conclusions

Further deployment of solar panels on existing residential buildings is a key requirement to speed up decarbonisation. Against the background of decreasing financial incentives for renewables, successfully extending the demand for residential solar energy beyond the eco-niche (Villiger et al., 2000 [7]) or innovators and early adopters will be needed, so that the "early majority" or "light green" customers will be reached (Rogers, 1995 [5]; Wüstenhagen et al., 2003 [6]). The success of such an endeavor will crucially depend on the ability to meet the preferences of homeowners who face the option to install solar panels in the context of a building retrofit.

Adding to the literature on the drivers of past solar adoption, this study focuses on the next generation of solar adopters and identifies two different segments of likely solar adopters, including a premium segment featuring higher willingness to pay for coloured and building integrated solar panels, and a value segment with more

price-sensitive customers. In addition to that, differences between likely adopters and likely non-adopters of solar panels in the context of the next roof-retrofitting project, as well as between the two prospective segments of likely adopters, are investigated along socio-demographic, psychographic and social indicators. A number of marketing and policy recommendations can be drawn from the results of the study.

First, likely adopters differ from likely non-adopters regarding their opinion on the visual appeal of solar panels installed on buildings, with the latter considering them unattractive and in general not suit for the exterior appearance of buildings. We find out that households' intention to install significantly correlates with the perceived visual attractiveness of solar panels. This suggests that changing the perception of solar panels' appearance and suitability to buildings' look is important for adoption in the later phases of diffusion of solar. This can be done through investing in improving the aesthetic aspects of the technology. However, our analysis also shows that a significant share of the future customers of solar panels would not be willing to pay a premium for their beauty and visual appeal, as they care more about the budget. In fact, our findings point to substantial heterogeneity in tastes among the surveyed homeowners. Data on Swiss homeowners indicate that, even in an affluent country, slightly less than half of the homeowners would not install solar panels in the context of their next roof renovation, while the other half would be almost evenly divided into two distinct segments of likely solar panels' adopters, including a premium and a value segment. The latter would choose a conventional lower-priced option with rack-mounted solar panels. The former, in contrast, would feature higher willingness to pay for colored and building integrated solar modules. This implies that a "one-size-fits-all" approach is hardly useful for solar panels' marketing purposes; instead, tailored product differentiation based on preferences of the identified customer segments would be advisable. The marketing recommendation is therefore changing the perception of solar panels' appearance and suitability to buildings' look, and going for product differentiation to meet different customer preferences and price-sensitiveness: some manufacturers should focus on cost leadership and target the value segment, while other ones on developing high-priced design solutions suit for the premium customers.

Second, results also suggest that, not just spatial peer effects, but also friends' and family members' choices matters for the intention to install solar panels: strong preferences for adoption correlate positively with the number of neighbors, friends and family members who already installed solar. We also find supporting evidence for the finding by Curtius et al. (2017) [13], who argue that believing that installing solar panels is the "right

thing to do” (i.e. a commonly approved behavior by a person’s social reference group) significantly increases homeowners’ intention to adopt solar energy; while we show that informational exchange between potential adopters and past adopters is not a key factor for adoption. This opens a new route for marketers and policy makers who want to leverage on social contagion effects. For instance, the visibility of existing solar panels could be increased among acquaintances by using referral marketing solutions when selling solar panels and by implementing a “solar energy adopter check” on social network profiles which quickly informs one’s network about her/his choice about going solar; moreover, a selected group of well-connected and influential people could be stimulated to adopt solar and asked to publicly endorse such choice; alternatively solar panel marketers and policy makers might disclose information on how many people working in a company, attending a given university or affiliated to a given association have already installed solar.

Third, the customer segmentation provided here can be of interest for budget-constraint policy makers aiming at fostering residential solar, too. In particular, anticipating who are the roof-renovators most and least willing to adopt solar energy can be instrumental for targeting incentives specifically towards a group of consumers different to those who would otherwise adopt. In this regards, our data suggest that female homeowners are less likely than male ones to choose solar energy when undertaking a building retrofit and that non-adopters are more likely to be capital constrained, hence policy makers may consider the gender dimension and potential adopters’ liquidity constraints when designing support schemes.

Fourth, marketers should be aware that, while sociodemographic features do not help very much in distinguishing the premium segment from the value segment, the importance that people assign to visual product appeal in their general purchasing decisions and their environmental attitudes do. More precisely, willingness to adopt innovative premium solar products, such as colored BIPV, is likely to come from product design lovers and from the greenest people. Marketing recommendations from these findings include placing advertisements for colored BIPV in design magazines, or promoting colored BIPV in design hotels or galleries, or collaborating with star architects when equipping high-profile public buildings with colored BIPV, in order to foster acceptance within the architects’ community.

This study is subject to some limitations which can serve as starting points for further research.

First of all, the results of the segmentation, and hence the estimated size and composition of each consumer group, crucially depend on the assumptions we made in the market simulation scenario about roof-retrofit solutions available on the market and are based on data for one particular country (Switzerland). The three options considered here are deemed to be consistent with a very realistic scenario for the Swiss solar residential market, but we should highlight that, even in an affluent country where the theoretical market potential is far from being saturated, the share of solar panels' adopters and their profile heavily depend on the features of the products offered on the market. Replicating the analysis in other countries, with different income level and different importance assigned to product aesthetics, would help in asserting to what extent the results, and in particular the role of visual appeal and the size of the premium segment, are generalizable beyond the (wealthy) Swiss context.

Second, the adopted technique does not allow to infer causality - which may deserve further analysis, for instance as the role of gender is concerned - nor it allows to quantify the impact of each significant factor on the willingness to pay for solar panels; it would be hence interesting to complement the univariate non-parametric analysis with multivariate statistical analysis that regresses the likelihood to be in one segment on the adopter's features addressed in the present paper and assesses interaction between different factors. Third, additional adoption drivers explored in the literature (such as level of unemployment, population density, political preferences/affiliation, house ownership) could be included in future research which has access to such data.

6. Bibliography

- [1] Lucon O, Ürge-Vorsatz D, Zain Ahmed A, Akbari H, Bertoldi P, Cabeza LF et al. Buildings. In: Edenhofer, O, Pichs-Madruga R, Sokona Y, Farahani E, Kadner S, Seyboth K et al. Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge and New York: Cambridge University Press; 2014. P.671-738
- [2] IEA. New business models for power: Setting the scene.
https://www.iea.org/media/workshops/2017/rewpworkshop2017/New_business_models_for_power_Setting_the_scene.pdf [accessed 22 August 2017].
- [3] Bergek A, Mignon I, Sundberg G. Who invests in renewable electricity production? Empirical evidence and suggestions for further research. *Energy Policy* 2013; 56: 568-81.
- [4] Karneyeva Y, Wüstenhagen R. Solar feed-in tariffs in a post-grid parity world: The role of risk, investor diversity and business models. *Energy Policy* 2017; 106: 445-56.
- [5] Rogers EM. Diffusion of Innovations. 4th ed. New York: Free Press; 1995.
- [6] Wüstenhagen R, Markard J, Truffer B. Diffusion of green power products in Switzerland. *Energy Policy* 2003; 31(7): 621-32.
- [7] Villiger A, Wüstenhagen R, Meyer A. Jenseits der Öko-Nische. Basel: Springer; 2000.
- [8] Dharshing, S. Household dynamics of technology adoption: A spatial econometric analysis of residential solar photovoltaic (PV) systems in Germany. *Energy Res. & Soc. Science* 2017; 23: 113-24.
- [9] Balta-Ozkan N, Yildirim J, Connor PM. Regional distribution of photovoltaic deployment in the UK and its determinants: a spatial econometric approach. *Energy Economics* 2015; 51: 417-29.
- [10] Briguglio M, Formosa G. When households go solar: Determinants of uptake of a Photovoltaic Scheme and policy insights. *Energy Policy* 2017; 108: 154-62.
- [11] Sigrin B, Pless J, Drury E. Diffusion into new markets: evolving customer segments in the solar photovoltaics market. *Environmental Res. Letters* 2015; 10(8): 084001.
- [12] Hille SH, Curtius HC, Wüstenhagen R. Red is the new blue – The role of color, building integration and country of origin in homeowners' preferences for residential photovoltaics. *Energy and Buildings* 2018; 162: 21-31.
- [13] Curtius HC, Hille SL, Berger C, Hahnel U, Wüstenhagen R. Spatial neighborhood effects in the adoption of solar photovoltaics. Unpublished 2017.
- [14] Scarpa R, Willis K. Willingness-to-pay for renewable energy: Primary and discretionary choice of British households' for micro-generation technologies. *Energy Economics* 2010; 32(1): 129-36.
- [15] Faiers A, Neame C. Consumer attitudes towards domestic solar power systems. *Energy Policy* 2006; 34: 1797–806.
- [16] Tabi A, Hille SL, Wüstenhagen R. What makes people seal the green power deal?—Customer segmentation based on choice experiment in Germany. *Ecological Economics* 2014; 107: 206-15.
- [17] Bloch PH, Brunel FF, Todd JA. Individual Differences in the Centrality of Visual Product Aesthetics: Concept and Measurement. *J. of Consumer Res.* 2003; 29(4): 551–65.
- [18] Simpson G, Clifton J. Testing Diffusion of Innovations Theory with data: Financial incentives, early adopters, and distributed solar energy in Australia. *Energy Res. & Soc. Science* 2017; 29: 12-22.
- [19] Schaffer AJ, Brun S. Beyond the sun—Socioeconomic drivers of the adoption of small-scale photovoltaic installations in Germany. *Energy Res. & Soc. Science* 2015; 10: 220-7.

- [20] Rode J, Weber A. Does localized imitation drive technology adoption? A case study on rooftop photovoltaic systems in Germany. *J. of Environmental Economics and Management* 2016; 78: 38-48.
- [21] Islam, T. Household level innovation diffusion model of photo-voltaic (PV) solar cells from stated preference data. *Energy policy* 2014; 65: 340-50.
- [22] Ebers A, Wüstenhagen R. 5th Consumer Barometer of Renewable Energy, May 2015, St.Gallen University.
- [23] Heinsteins P, Ballif C, Perret-Aebi LE. Building integrated photovoltaics (BIPV): review, potentials, barriers and myths. *Green* 2013; 3 (2): 125-56.
- [24] Hampton G, Eckermann S. The promotion of domestic grid-connected photovoltaic electricity production through social learning. *Energy, Sustainability and Society* 2013; 3 (1): 23.
- [25] Graziano M, Gillingham K. Spatial patterns of solar photovoltaic system adoption: the influence of neighbors and the built environment. *J. of Economic Geography* 2014; 15(4):815-39.
- [26] Leenheer J, De Nooij M, Sheikh O. Own power: motives of having electricity without the energy company. *Energy Policy* 2011; 39: 5621-9.
- [27] Sardianou E, Genoudi P. Which factors affect the willingness of consumers to adopt renewable energies?. *Renewable energy* 2013; 57: 1-4.
- [28] Baranzini A, Carattini S, Péclat M. What drives social contagion in the adoption of solar photovoltaic technology? Working Paper 2007, HES-SO Geneva
- [29] Chen KK. Assessing the effects of customer innovativeness, environmental value and ecological lifestyles on residential solar power systems install intention. *Energy Policy* 2014; 67: 951-61.
- [30] Schelly C. Residential solar electricity adoption: what motivates, and what matters? A case study of early adopters. *Energy Res. & Soc. Science* 2014; 2:183-91.
- [31] Bollinger B, Gillingham K. Peer Effects in the Diffusion of Solar Photovoltaic Panels. *Marketing Science* 2012; 31(6): 900-12.
- [32] Jager W. Stimulating the diffusion of photovoltaic systems: a behavioural perspective. *Energy Policy* 2006; 34: 1935-43
- [33] Rai V, Robinson SA. Effective information channels for reducing costs of environmentally-friendly technologies: evidence from residential PV markets. *Environmental Res. Letters* 2013; 8(1): 014044.
- [34] Brudermann T, Reinsberger K, Orthofer A, Kislinger M, Posch A. Photovoltaics in agriculture: a case study on decision making of farmers. *Energy Policy* 2013; 61: 96-103
- [35] IEA. Photovoltaic Power Systems Programme, 2017. <http://www.iea-pvps.org> [accessed 22 August 2017].
- [36] KEV Stiftung. Data on grid-connected photovoltaic systems. <http://www.stiftung-kev.ch/berichte/kev-cockpit.html> [accessed 22 August 2017].
- [37] Johnson RM, Orme BK. A new approach to adaptive CBC. *Proceedings of Sawtooth Software Conference*; 2007; Sequim, WA.
- [38] Cooper DR, Schindler PS, Sun J. *Business research methods*. vol. 9. New York: McGraw-Hill Irwin; 2006.
- [39] Karrer et al. Technikaffinität erfassen – der Fragebogen TA-EG, https://www.researchgate.net/publication/266876811_Technikaffinitat_erfassen_-_der_Fragebogen_TA-EG; 2009 [accessed 28 February 2018].
- [40] Dunlap RE, Van Liere KD, Mertig AG, Jones RE. New Trends in Measuring Environmental Attitudes: Measuring Endorsement of the New Ecological Paradigm: A Revised NEP Scale. *J. of Soc. Issues* 2000; 56: 425-42.

- [41] Sawtooth Software. The CBC/HB system for hierarchical Bayes estimation version 5.0 technical paper, <https://www.sawtoothsoftware.com/support/technical-papers/hierarchical-bayes-estimation/cbc-hb-technical-paper-2009> [accessed 28 February 2018].
- [42] Orme BK. (2010). Getting started with conjoint analysis: strategies for product design and pricing research. Research Publishers; 2010.
- [43] Sawtooth Software. Client Conjoint Simulator, <https://www.sawtoothsoftware.com/download/techpap/ccsmanual.pdf> [accessed 28 February 2018].
- [44] Sawtooth Software. Latent class vs. clustering by purchased product, <https://sawtoothsoftware.com/forum/8522/latent-class-vs-clustering-by-purchased-product> [accessed 28 February 2018].
- [45] PVtech (2017). Top-10 solar cell producers in 2016, <https://www.pv-tech.org/editors-blog/top-10-solar-cell-producers-in-2016> [accessed 28 February 2018].
- [46] Straughan RD, Roberts JA. Environmental segmentation alternatives: a look at green consumer behavior in the new millennium. J. of Consumer Marketing 1999; 16(6): 558-75.