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Rethinking the social acceptance of solar energy: Exploring "states of willingness" in Finland

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ABSTRACT

Although most studies present willingness to adopt as a pre-adoption facet, very few studies can be found that include pre- and post-adoption willingness factors/conditions in adopting solar energy. This study was carried out to explore public willingness to adopt solar energy in residential areas through the lens of different states (stages) of willingness to adopt, and consequent patterns of social acceptance. This qualitative study found the existence of four states of willingness to adopt solar energy among laypersons and expert Finnish respondents, forming quadrants in the interplay between decision and actions. This gave rise to five segments of customers, most representing the 'acceptance in principle' pattern of social acceptance. The results of this study emphasize the necessity for an effective and meaningful approach to those states of willingness to adopt in the growth and diffusion of renewable energy technologies such as solar energy.

1. Introduction

Although solar energy is no longer a new technology in the global context, it is a new and innovative energy source to laypersons in different local contexts. There is a vast amount of work still left to do in different country contexts in terms of customer segmentation ('who would adopt'), targeting, and positioning of solar energy to achieve competitive advantage in the energy industry market [1,2]. To create a market for a new product or innovation, it is important to look at and find the relevant customer segments [3]. Based on who is more or less willing to adopt, a search for different states of public willingness would assist in differentiating the customer segments. For creating market opportunities and for encouraging social acceptance at the individual level, the comprehension of individual willingness to adopt (WTA) solar energy technologies is crucial. Subsequently, this will direct 'who to approach' and, then, 'how to approach' them for the growth of the market.

This study was carried out in Finland to contribute to addressing this gap aided by qualitative semi-structured interviews with Finnish respondents (see Section 3). Although southern areas of Finland have an annual solar irradiation that almost equals northern Germany, traditionally solar energy has had a weak image in the country [4,5]. Although most Finnish citizens prefer solar energy to other renewable energies [6,7], its adoption rate is still surprisingly insignificant. According to Statistics Finland [8], in its already achieved ambitious '20-20-20 targets' of 38% renewable energy share of national consumption in 2014, there was no solar energy contribution. The country has only two solar district heating based communities, among which only Eko-Viikki in Helsinki is still in operation, although with some shortcomings [9]. It is only recently that the country has started to concentrate its attention on solar energy as a response to the accelerating global solar energy market share and seeing countries with similar solar irradiation and weather conditions that have been able to advance in the technology [10]. Although some business models already exist in the market, namely turn-key solutions, the facilitator model, utility-side solar photovoltaics (PV), and the joint purchase model, many people are not aware or have inaccurate knowledge of them [11,12]. Such models also expose diverse 'segments of potential adopters' ([13], p. 504). In Finland, solar energy is approaching new market formation and gradually attracting new customer segments [10,12,14]. According to a 2014 report [15], in the next 5–10 years, the number of installations of household/individual solar power systems is estimated to be approximately 150,000. Since the individual installation of solar energy systems has been the major and fastest-growing segment in Finland [16,17], an exploration of it based on WTA tendencies could further intensify the diffusion of solar energy in the country (for further clarification see Sections 2.3 and 2.4). Furthermore, an understanding of segments following a 'human-centred approach' (how consumers act and make their decisions) would help to understand market acceptance and consequently social acceptance of solar energy. By understanding social acceptance through customer segmentation, it would be possible to specifically determine the public tendency to adopt that is obscurely

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presented in the concepts of social acceptance stated in Section 2.5 (especially in terms of the broad concept of 'acceptance in principle'): it would be clearer who the adopters are and what the nearness of other categories of the public towards adoption is. Moreover, it could also direct ways to attract more customers towards adoption. With such notion in this study, three research questions were posed:

(1) What are the states of public WTA solar energy?
(2) How can different customer segments be identified through those states of public WTA solar energy?
(3) How would those customer segments determine different patterns of social acceptance?

This study could benefit customers if their needs were heard by the support and service providers. The recommendations presented in Section 5 could be of interest to policymakers and marketers to support the growth of clean energy technologies such as solar energy. The links between states of WTA, customer segmentation, and social acceptance could attract and provide insights for researchers and academics to conduct further studies.

The next section presents a review of relevant literature. Section 3 describes the conceptual framework and methodology of this study. In Section 4 research results are presented and discussed. Section 5 includes the conclusions, recommendations, and direction for further research.

2. Literature review

2.1. Visibility of willingness to adopt solar energy in the literature

Human choice (dominated by various personal and contextual conditions, see Section 2.3) is a critical and controlling matter in energy use, especially in how consumers act and make their decisions. Qualitative studies are crucial to bring out the human factors to adopt and to visualize the changing landscape in the solar market. Sovacool [18] in a study found that only 12.6% of 4444 papers used a qualitative approach in energy studies. For this paper by conducting an advanced search in the ScienceDirect database [19,20] using the 'willingness to adopt solar energy' option refined by year (2000–2016) and 'journals', a total of 1916 results were generated. Later, the data were filtered by 'topic' (solar) and the output became 54. Out of those, only 12 relevant studies conducted hitherto emphasized individual willingness to pay (e.g [21–28].), willingness to invest (e.g. [28–31],), willingness to try/use/do/adopt (e.g [24,26,29,30,32].), willingness to reduce [28] and willingness to change (e.g [21,22,27,33].) issues in obtaining renewable energy in general and solar energy in particular. Just one article [28] dealt with the stated search topic in its literature review. Consumer Focus [34], cited in the literature review of [28], in its survey among the UK population identified variations in age groups at pre-consideration, consideration, preparation and adoption stages of micro-generation adoption and some barriers and drivers that do not explain any states of WTA or patterns of customer segments.

2.2. Willingness to adopt solar energy in Finnish studies

Although there are some Finnish studies that directly or indirectly emphasize human-centred approaches to adopt solar energy (Appendix A) by stating various barriers and policy recommendations [5,35,36], very few of them have focused on customer segmentation (e.g [5,37].). However, concentration on segmenting 'individual' customers based on WTA tendency is scarce. In a recent quantitative study, Kahma and Matschoss [38] present different Finnish customer segments based on some demographic factors such as age, gender, education, income and types of residence by knowing their patterns of non-use or rejection of smart energy services and the accompanying reasons. Another Finnish study segments residential adopters of solar power in terms of age groups (young, middle age and older people), price-sensitive groups (rich and other people), geographically-concentrated groups (people living in southern Finland and other regions) and other groups (environmentally enthusiastic and new technology loving people) [12]. Child et al. [5] argue that in some market segments grid parity has been reached by solar energy, which is expected to be more competitive on its own in the future. Heiskanen et al. [16] argue that between 2009 and 2013 most of the investments in solar energy in Finland were made by individuals (households). Among other market segments, non-profit organizations, agriculture and forestry, the service sector, other industries, and energy companies, etc. had invested in solar energy.

2.3. Factors/conditions affecting willingness to adopt solar energy

Different personal and contextual factors (conditions) can determine individual WTA tendency. Personal factors such as motivation and nature of individuals, age, income, occupation, lifestyle, need, knowledge and interest, and/or contextual factors – socio-political, community, market situations – jointly and/or individually can direct people to the adoption or non-adoption of a proposed technology [5,35,38,39]. They can play a significant role at pre- and post-adoption stages by inhibiting or promoting adoption of an innovation [40]. In renewable energy adoption, both pre-adoption and post-adoption willingness factors/conditions are important to consider. Most of the studies mentioned in this paper are mainly based on the pre-adoption factors. However, a few studies were found that dealt with post-adoption factors – mostly where the roles of adopters were assessed in repurchasing or referring others (peer effects) to solar energy [9,41]. The likelihood of adopting solar PV increases and the duration of decision time decreases because of positive peer effects [42,43]. There is a possibility that after adoption one may no longer 'want' to continue it. A discontinuation will result in non-adoption and rejection [44]. A discontinuation of solar may occur, for instance, through the withdrawal of solar, wind and hydropower based 'environmental electricity' and starting to use popular 'basic electricity' since the former costs higher than the latter (see [45]). High mobility among low-income residents living in solar shared communities or community solar gardens (e.g. Colorado's Community Solar gardens programme) 'every few years' creates discontinuation of the service (see [46]). There is also evidence that system failure and excessive cost involved in Kerava Solar Village in Finland to meet the heating demands among dwellers of 44 houses forced them to discontinue the solar heating and to rely on the local district heating system [9].

2.4. Willingness to adopt solar energy, decision-making, and customer segmentation

People do not take the decision to adopt solar power in a vacuum [13]. They rely on various personal and contextual factors. The diffusion of an innovation depends on the individuals' decisions, based on their beliefs, traditions, and outlooks [47]. Following Rogers [44] it can be said that the willingness of an individual as a reflection of his/her knowledge and persuasion is deciphered into his/her decision to adopt or reject an innovation. Individuals have to make a decision and perform actions that would confirm their adoption status [44]. Furthermore, such decisions and actions can vary from person to person. For instance, among Rogers's five categories of adopters the 'innovators' (intrinsically technology loving enthusiasts who proudly enjoy new products even with uncertainties) mostly reflect their personal motivation and individual nature in their adoption of an innovation. 'Early adopters' (visionaries who want to exploit new technology to gain an edge over the status quo) and 'early majority' people (pragmatists and risk-averse people who adopt/buy a new technology from the leading company after confirmation by the product proven track record of delivering value) reflect their personal motivation and contextual conditions in their adoption decision, implementation and confirmation. A

coercive role of contextual conditions can be seen among the 'late majority' type of adopters (risk-averse conservatives who are being forced to adopt an innovation although remain doubtful about the value-driving potential of the product) and 'laggards' (sceptics who are very wary about new technology, have bias for criticizing it and hate change). So, following Rogers's explanation, it can be said that both personal motivation and contextual conditions can individually and/or jointly influence people towards adoption. According to Kotler and Keller [1], following a behavioural segmentation approach based on 'user status' five main users can be found: (a) non-users, (b) ex-users, (c) potential users, (d) first-time users and (e) regular users. Each segment has its own expectation related to a product or service. There are also some segmentations based on demographic characteristics (age, gender, religion, marital status, income, occupation, purchaser or user, etc.), geographic location (region and country variations), and psychology (personality, lifestyle, and self-concept) [1,2]. Although these segmentations are broad, they specifically focus on those who will unconditionally adopt and/or use the product. The present study also aimed to identify different patterns of customer segments through the lens of different states of WTA solar energy in relation to the confirmation of individual decision and actions.

2.5. Willingness to adopt solar energy and social acceptance

In clean energy studies, increasing focus on social acceptance can be observed because it gives social licence for such energy technology deployment, and adoption, non-adoption, and diffusion issues are largely dependent on it [48,49]. Although the multidimensional nature of social acceptance covers many aspects, different states of social acceptance can be observed at various levels of public decision and action. Acceptance by an active user is called actual adoption, adoption or active acceptance [49–52]. In consumer behaviour and conventional marketing theories, the actual adoption or consumption of goods and services by consumers has always been the focus [53]. Acceptance by a positive-minded non-user is termed 'in principle' or passive acceptance. It includes those who postpone adoption due to a lack of minor or major conditions but who are positive minded. Furthermore, it would be difficult to say that acceptance in principle always includes positive-minded non-adopters – there could be some positive or negative minded people who are unaware of or reluctant about a product or technology [54]. Those who reject or oppose fall in the rejection or opposition category respectively [49,55]. Rejection is defined as the decision to not accept an innovation [44]. If consumers are convinced of the unsuitability of a product or an innovation and decide to exert innovation/product sabotage actions (e.g. negative word of mouth), it is called opposition [55]. Those who are in opposition to an innovation not only reject it but also oppose it. In that sense, it can be said that opposition is a stronger form of rejection. So, this study also set out to look at how those customer segments determine different patterns of social acceptance of solar energy technology.

3. Materials and methods

For the sake of this research, the willingness of those who have already adopted solar energy technology by confirming their positive decision and actions to adopt based on some personal and/or contextual conditions is considered 'activated willingness'. If a product or technology is sold to and/or adopted by consumers, from a business perspective [53] it is considered to be a positive action. A negative action can be represented by a negative situation (i.e. a product or technology not being sold and/or adopted by consumers). Product- sabotage actions such as negative word-of-mouth (about high upfront cost, no household investment support in Finland) are explicitly confirmed negative actions. Furthermore, the inaction of non-adopters, perhaps implicitly, can also be considered as a negative action since it does not add value to the market growth of a product or technology. Confirmation and non-confirmation levels are determined by the decision, current status and actions of the customers. Some studies confirm that there are some customers who would adopt solar energy even with no change in the present support schemes in Finland [4,5]. So, their willingness is considered 'unconditional willingness'. Furthermore, it can be said that these non-adopters have already confirmed their positive decision and their non-adoption status will vanish over time [4,5,38]. Their current non-adoption status does not mean that they have performed negative actions to adopt. In that sense, their current non-adoption status can be treated as unconfirmed negative action.

Some people decide to adopt solar energy on the understanding that certain conditions will be met in the future (e.g. investment support for individuals, feed-in-tariff etc.). Some would also decide to adopt but only after seeing those conditions fulfilled [52]. Their willingness is considered 'conditional willingness' to adopt. They have not yet confirmed their negative decision, and their positive action to adopt is still unconfirmed. It is a common fact that some customers will not adopt solar energy or other products available in the market. Moreover, some barriers (e.g. unsuitable weather conditions, lack of support schemes) can be the potential reasons for their non-adoption and active resistance [38]. So, their willingness related to non-adoption of solar energy is considered 'unwillingness'. These people confirm their negative decision to adopt and also in action they do not adopt.

Generally, existing users and/or adopters can be termed adopters and the rest of the people non-adopters. For customer segmentation, those who have 'activated willingness' are categorized as 'activated WTA adopters'. Those who have unconditional willingness are termed 'unconditional WTA would-be adopters'. People who have conditional WTA and have decided to adopt once some conditions are fulfilled are termed 'conditional WTA would-be adopters'. Those people who have conditional WTA and who would make the adoption decision once some conditions are fulfilled are termed 'conditional WTA non- adopters'. Those who do not have any WTA or may create product sabotage actions are termed 'non-WTA non-adopters'. Finally, following the states of WTA and patterns of customer segments the emergence of some patterns of social acceptance can be seen: 'activated WTA adopters' represents 'adoption', 'unconditional WTA would-be adopters', 'conditional WTA would-be adopters' and 'conditional WTA non-adopters' represent 'acceptance in principle', and 'non-WTA non-adopters' represents 'rejection' and 'opposition'.

Based on the stated literature initially as an outcome of pre-testing of the research in Eko-Viikki residential area in Helsinki this study determined the key terms (related to states of WTA and customer segments) and the conceptual framework was developed (Fig. 1). Like some previous qualitative studies (Appendix A), two sets of data collection plans are presented in this paper where the sample also represents experts and the most actively interested (users and non-users) group of Finnish respondents.

Based on the Finnish context of solar energy (Section 1) it was considered difficult to find out both adopters and non-adopters in random places. So, this study was at first conducted in the Eko-Viikki, which includes different categories of customer segments in terms of their adoption status (i.e. adoption, acceptance in principle, rejection and opposition) caused by the presence of some solar integrated (solar community concept) and normal blocks of flats, and detached and semi-detached houses where owners, tenants and right-of-occupancy dwellers can reside [56]. Furthermore, it was necessary to observe post-adoption factors. By adhering to purposeful sampling using the maximum variation strategy [57], this study was conducted using 25 local Finnish residents (12 males and 13 females) who were available, had something to say, and were willing to spend time providing information and sharing their life experiences in English (e.g [58]). They were recruited mainly on the weekends when they were observed walking around and spending leisure time in the locality (in the open fields, roads and with children in the playgrounds). For 'maximum variation', the interviews were continued until all categories of respondents (in

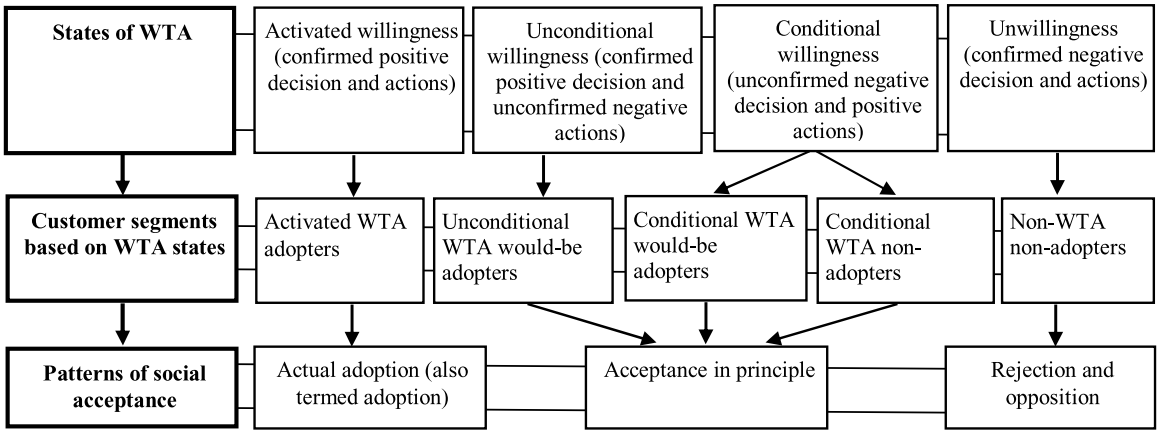

Fig. 1. Conceptual framework of the study: states of willingness to adopt (WTA), customer segments based on WTA states, and consequent patterns of social acceptance.

terms of their adoption, acceptance in principle, rejection and opposition) and the information they provided was repeated multiple times. Although repeated visits were made on the weekends to the location, unfortunately, the 'opposition' category was not found there. Those laypersons only offered their opinion about this category.

To get in-depth and generalized information, the second set of data was collected from leading and representative Finnish experts. Expert opinions were considered crucial to include and to explore their own states of willingness and the overall picture of WTA tendency among Finnish citizens. In their opinion, all types of adoption status were explored. The most extensively used was 'snowball sampling' to get more in-depth research data from 17 Finnish experts (11 males and 6 females) [59]. Following a link-tracing referrals strategy, initial request e-mails with proper reference and research objectives were sent to them and they were recruited based on their expertise and appointment (place and time) preferences. These experts held important positions in different organizations including, for instance, the Finnish Ministry of Economic Affairs and Employment, Bioenergia ry, Aalto University, Tekes –Finnish Funding Agency for Technology and Innovation, SITRA – Finnish Innovation Fund, FREF– Finnish Real Estate Federation, EKOenergy, SYKE – Finnish Environment Institute, Helen Ltd. – Helsinki energy company, HSY – Helsinki Region Environmental Services Authority, City of Helsinki Environment Centre, NIBE Energy Systems Limited, HKR –Helsinki City Buildings, Utuapu Oy, and City of Helsinki Urban Development Areas. Some experts represented different units/divisions of the same organization.

Table 1 presents demographic profile of respondents. The respondents were given full freedom to participate in or avoid the interview process. Mainly sticking to the exploratory goals of the study, some interviewing steps were pre-specified. For example, before conducting the interview, respondents were provided with the background of the research. They were also assured that their opinions would anonymously be handled to conceal their identity. To derive maximum information, rapport building with the respondents was found helpful [60]. Since respondents' richness and in-depth and relevant insights into the questions under study were fundamental to the research findings [61], laypersons and experts were requested to be mentally prepared to spend at least 25-minutes and 45-minutes in the interview respectively, according to the nature of the questions and their responses to them. They were asked to provide their answers to the research questions stated in Section 1. Face-to-face interviews covered the following topics: (1) the identification of different states and the nature of public WTA solar energy, (2) the identification of different customer segments based on those states of WTA solar energy, and (3) the determination of different patterns of social acceptance through those customer segments. Initially, the respondents were asked to provide information about their age, gender, occupation, education, and solar energy adoption status. Those questions were avoided for most of the experts, whose information was already known. To find out the answers to the research questions, respondents were asked to provide information and their opinion about the solar energy adoption tendency among Finns and themselves, their awareness of this energy in a Finnish context, and their patterns of willingness, characteristics and related expectations towards adoption. They also discussed barriers and routes to increase the rate of solar energy adoption in Finland. However, experts provided more generalized responses than laypersons. While conducting the semi-structured interviews, probing questions were used to gather the maximum amount of information, and the respondents could add any thoughts they considered relevant [62].

Collected primary data were analysed using the qualitative content-based theme analysis technique [63]. Content analysis induced research findings were presented with different logic about and reflections on the stated literature [63]. To unveil the ideological meaning of the research topic based on the responses, the interviews were audio-taped and later transcribed by considering and determining the context of the content, the interpretation and the tone [18]. While analysing empirical data following an inductive process of analysis, the identified variables/categories were allowed to emerge on their own. A descriptive and analytical representation [64] of those findings is given in Section 4. This study was a little constrained by language problems during the interviewing of the laypersons. However, they tried to explain different Finnish terms in English, which helped the researcher comprehend their opinion. The results thereby generated, offer evidence and valuable suggestions about matters related to different states of public WTA customer segments based on those WTA states and consequent labels of social acceptance in a broader context.

Table 1
Demographic profile of respondents (only Finns).

Variables	Options	No. of laypersons	No. of experts	Total
Age (n = 42)	(21– 30) years	3	0	3
	(31– 40) years	13	6	19
	(41– 50) years	5	5	10
	(51– 60) years	4	4	8
	(61– 70) years	0	2	2
Gender (n = 42)	Male	12	11	23
	Female	13	6	19
Education (n = 42)	Vocational and/ or upper secondary	2	0	2
	Bachelor's	13	2	15
	Masters	10	13	23
	PhD and above	0	2	2

4. Results and discussion

4.1. Different states of willingness to adopt

The statements given by laypersons and experts considering pre-adoption and post-adoption willingness status, when synthesized, offered four states of public WTA solar energy. The first WTA state is *activated willingness*, which is synonymous with actual adoption. This state of WTA solar energy is instrumental to the growth and development of the solar market. Three laypersons fell into this category. To laypersons, such willingness was linked to the sustainability criteria of the Eko-Viikki residential area and was one of the reasons for purchasing a flat in the solar energy integrated block of flats. However, while conducting the fieldwork in Eko-Viikki it was also observed that in some of the houses enthusiastic laypersons had installed solar panels, but none of these people were available and/or approachable at the time of interviewing. Respondents considered such adoption to be a reflection of solar building demonstrations in Eko-Viikki. Some expert respondents also provided information about their own installation of solar energy technology in their houses. Stating such willingness as a reflection of personal motivation, one expert working at Helen argued:

> In the case of solar panels, those who have them in their residential places now, they are kind of trendsetters. These kinds of people are mostly the engineers or technically oriented, who want to have solar energy in their houses. So, it is a hobby thing for them. To them, it is limited and more expensive, but it is nice to do an experiment with that and so on.

The second WTA state is *unconditional willingness*. There may be some people who have WTA solar energy but have not yet confirmed their adoption actions. One laywoman had this kind of willingness. The common statement regarding this state of WTA was that the customers having WTA would soon start working on adoption actions, as also found by [38]. They lack the spare time and do not make the proper effort to start, as also observed by [65]. In the Helsinki metropolitan area, strong public willingness to financially invest in renewable

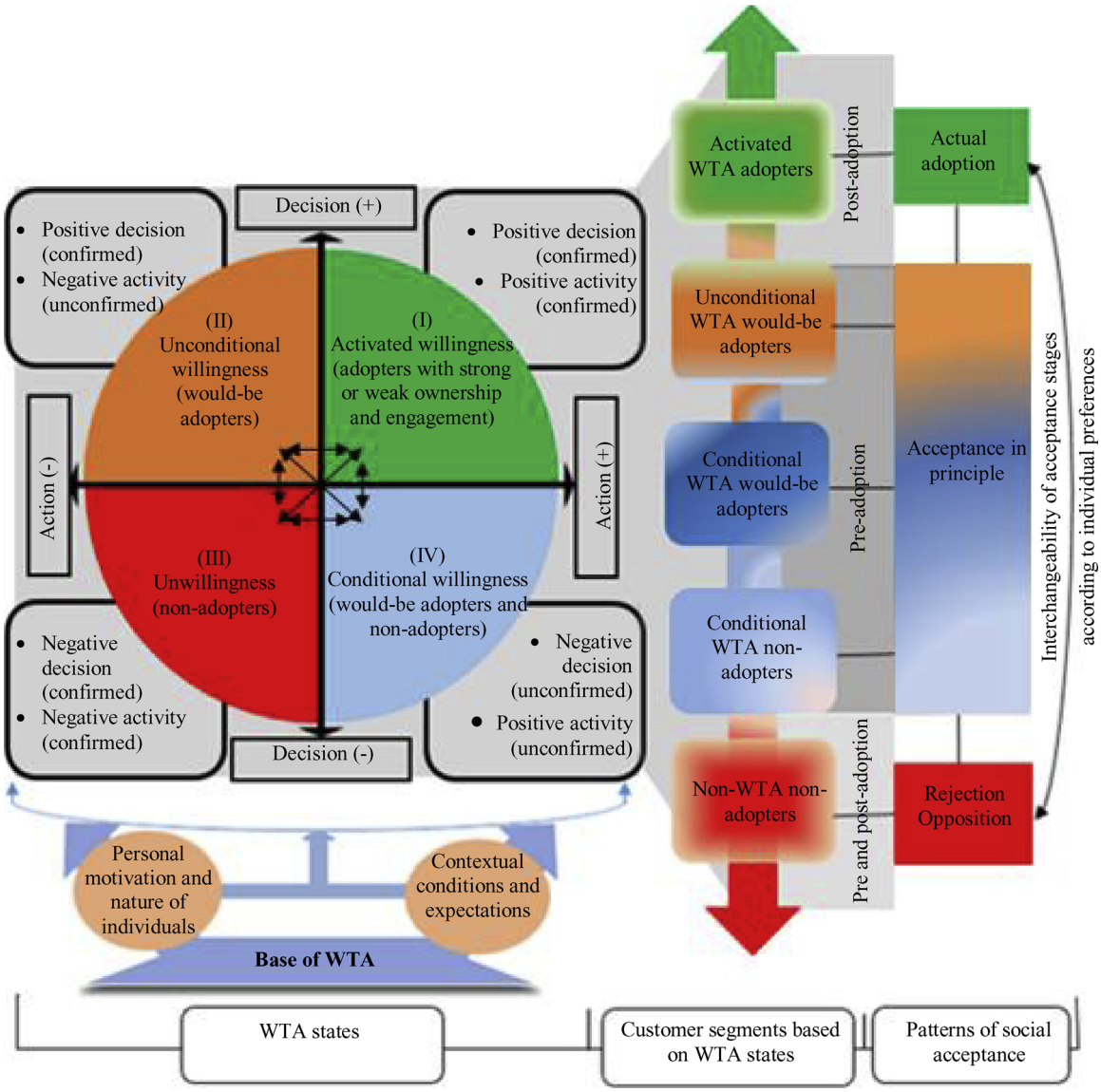

Fig. 2. States of willingness to adopt (WTA), patterns of customer segmentation and social acceptance. Potential adopters can move freely between the categories. The first indicates how four states of WTA solar energy are formed based on the decision and actions of individuals. The higher degree of consumer comfort with those actions and decisions increases the possibility or nearness to adopt and vice versa (see Table 2). The second indicates how five categories of customer segments are formed where various pre- and post-adoption conditions (Table 2) play a significant role. The third indicates how those customer segments represent different patterns of social acceptance.

energies was found by [52].

The third WTA variant is *conditional willingness,* which includes those people who have WTA solar energy but first want some conditions to be assured or satisfied. These conditions are more or less presented in the literature as the factors that attract people to adopt solar energy (see Section 2.3). The variant also includes those who are unaware or undecided because 'to be aware' and 'to decide' refer to some related actions as conditions for their final decision and actions. Twenty laypersons had this kind of WTA. Most strikingly, this state of WTA, directly and indirectly, received the maximum focus in the statements of laypersons and experts in varying ways. Most of the respondents believed that such conditional willingness could be found among most of the Finnish citizens. A few laypersons and experts stated that they had the intention to install solar energy technology, but they did not have their own house. Once they were to buy their own house, they would consider installing solar panels. One striking point was made by most of the expert respondents and a few laypersons. That is, positive-minded people were confused about installing solar energy technology since they did not hear any positive comments or see an allocation of specific support- services for individual installation from the government, as also mentioned by [4,5,16]. There is 50% labour cost support at household level in Finland that can be used for the installation of solar panels [12]. Furthermore, the respondents included that there may be some people who have not yet thought of installing solar power. Their weak (or no) willingness and their reluctance represent their non-adoption status.

The last state of WTA is *unwillingness* or non-WTA. It includes matters that go against WTA. One layman and one female expert having this state of WTA considered that solar energy would not be feasible in Finland. So, they expressed their full unwillingness to adopt solar energy. However, they stated that they would reconsider if at any time cost-effective technological breakthroughs arrive, the solar electricity price becomes lower than traditional grid electricity or investment in solar energy technology becomes cost-effective, as also discussed by [5].

Respondents could be shifted from their current state to any other of the four states of WTA based on their recognition of their needs and the availability/unavailability of different conditions in relation to their decision and actions (Fig. 2). The action of having or not having solar power is the outcome of actions related to need recognition, information search, evaluation of alternatives (i.e. products from different companies at different prices, warranties, services etc.), adoption and/or use (i.e. installation of solar panels or getting solar power from a provider), and post-purchase actions (e.g. referring other, discontinuation of solar power connection). These actions are also closely related to the decisions of consumers. The greater consumer comfort with those actions and decisions increases the possibility or nearness to adopt and vice versa (see Table 2). Although some expert respondents considered WTA an ever-fluctuating event and, therefore, considered it dynamic, such dynamism was not observed among respondents falling in the 'activated willingness' state of WTA. They did not discontinue their adoption. It was further observed that the stated states of WTA formed quadrants (see Fig. 2) in the interplay between decisions and actions, as described in the next section.

4.2. Confirmation of adoption/non-adoption decision in actions and customer segmentation

It was observed that some of the respondents considered personal willingness and efforts to be sufficient for a person to adopt solar energy. Furthermore, some stated that it would be unethical to demand subsidies and other support from the government for the adoption of solar power at an individual level. Such a tendency is also observed in the almost 'no subsidy' policy especially for household installations in Finland [5,16,66]. The most-commonly-mentioned statements included both personal motivation and different contextual conditions that could attract or demotivate public WTA solar energy. Furthermore, the experts stated mainly a lack of public understanding and/or appropriate information about the cost-benefit of investment, existing business models and available support that restrict the adoption rate.

In Fig. 2 the (I) quadrant represents the 'activated willingness' state of WTA, where there are both a confirmed positive decision and positive actions. The customer segment generated through this state of WTA can be termed *activated WTA adopters*. These customers have already adopted solar energy. Two variants of *activated WTA adopters* can be found: (a) *activated WTA adopters* as active adopters (involvement in installation), and (b) *activated WTA adopters* as passive adopters (non-involvement in installation). Three laypersons represented the second variant. The expert respondents who installed solar technology in their dwellings represented the first variant. The customer segment falling in this 'activated willingness' state of WTA was considered by the expert respondents to be 'the forerunner in this sector' (37-year-old expert respondent working at EKOenergy). This category of customer segment is environmentally enthusiastic and interested in new technology, as most of the experts and laypersons argued. For instance, one expert (employee of SYKE) argued: 'Of course, those people who are interested in the climate issue, energy issues and nature are the ones to install first and others that are interested in the technology'.

Quadrant (II) represents the 'unconditional willingness' state of WTA, where there are a confirmed positive decision and unconfirmed actions towards adoption. Since actions still remain unconfirmed, which prohibits the finalization and confirmation of adoption, it is therefore considered unconfirmed negative action. The customers generated through this state of WTA are termed *unconditional WTA would-be adopters*. Customers in this segment are those who are willing to install solar energy technology without any change in the current conditions. One laywoman, who had 'unconditional WTA' confirmed her positive WTA decision but did not confirm her actions to adopt. So, her adoption-related actions were deemed negative. She was motivated to adopt by the demonstrations of solar integrated buildings and the installation of solar panels by some households in Eko-Viikki. Respondents believed that customers falling into this category take their time to finally adopt, with some postponing it to avoid adoption-related responsibilities and because of a lack of proper knowledge about the existing business models for sourcing, purchasing and installing solar panels, grid connection, etc.

Quadrant (III) shows the 'unwillingness' state of WTA, where there are both a confirmed negative decision and negative actions towards adoption. The customers generated through this state of WTA are termed *non-WTA non-adopters*. During the interviews, the *non-WTA non-adopters* confirmed their negative adoption decision. One layman had expressed his rejection of solar energy considering the unfavourable weather conditions in Finland. One passive adopter purchased his apartment in a solar integrated building in Eko-Viikki from a previous owner who fell into discontinuation of adoption because of selling that property. Among expert respondents, there was just one opposing response, which was derived from one female carbon-neutral industry specialist. A long winter, high investment cost and long payback period forced her to be doubtful about the prospect of solar energy in the challenging context of Finland. Previous studies also mention these causes [5,9,35–37,56]. She did not find any reason why the government would offer to subsidize solar energy. Instead, she explained that much focus could be given to other renewable energy sources, for instance, bio-energy. She also emphasized solar thermal power storage issues, and she considered such heat power not cost-effective.

Quadrant (IV) shows the 'conditional willingness' state of WTA, which includes the unconfirmed negative decision, and unconfirmed positive actions towards adoption. Two customer segments can be seen generated through this state of WTA. The customer segment *conditional WTA would-be adopters,* the first variant, consists of those who show their WTA and have taken initial technology assessment (e.g. cost-effectiveness, feasibility) steps to decide to adopt solar energy once some

Table 2
Customer segments based on different conditions (WTA = willingness to adopt).

Pre-adoption conditions	Customer segments (with specific conditions)	Post-adoption conditions
New technology lovers; 'green' loving mentality; financially solvent; own house/apartment or not[a]; burning desire/ enthusiasm	Activated WTA adopters: prompt action and adoption Unconditional WTA would-be adopters: time constraint; laziness and/or sluggish initiative; lack of proper knowledge about existing business models for sourcing, purchasing and installing solar panels, grid connection, etc.	Continuation of adoption and/or use
Favour new– and environmentally sound technology but cost is main concern; financially solvent or insolvent; own house/ apartment or not[a]; unwilling to allow higher cost for solar power compared to cheap grid-based basic electricity; unwilling to rely on fluctuating solar power unless cost-effective backup solutions are available; look for different support (e.g. household investment support, net-metering, feed-in-tariff); want accurate, full and properly disseminated information about feasibility, investment cost and return, support structures and business models; want equivalent market price of produced solar energy by selling it to buyers; want to see more practical demonstrations and successful cases; look for political commitment[b]	Conditional WTA would-be adopters: initially have decided to adopt once all or most of the conditions are fulfilled Conditional WTA non-adopters: decision to adopt will be taken later once all or most conditions are fulfilled	
Financially solvent or insolvent; own house/apartment or not[a]; unwilling to allow higher cost for solar power compared to cheap grid-based basic electricity; unwilling to rely on fluctuating solar power caused by long winter mostly with a dark sky and short summer	Non-WTA non-adopters (rejection): unsuitability, unaffordability and/or non-profitability concerns Non-WTA non-adopters (opposition): against the technology because of unsuitability, unaffordability and/or non-profitability concerns	Discontinuation of adoption and/or use by changing energy source; selling property or moving to other location

[a] For green electricity connection owning a house or apartment is not compulsory. Renting a residence is sufficient since the tenants have to make their own contract with the energy company. Disregarding the fact of owning or renting an accommodation one could become an adopter by investing in a solar power plant (e.g. Helen's Suvilahti solar power plant).
[b] There is no specific target for solar energy in Finland (see [4,5,9]).

positive results come out that match their expectations. Otherwise, they will remain non-adopters. They exhibit an unconfirmed negative decision and unconfirmed positive actions to adopt before seeing the desired assessment results. Being influenced by stated demonstration buildings, adopters and some household installations, one layman and one laywoman showed their WTA solar panels in their common sauna, had a discussion in their annual housing committee meeting about them, and initially handed over the responsibility to their housing committee to assess the feasibility and investment factors/conditions.

Customers falling in the second variant, *conditional WTA non-adopters,* wait to decide and adopt until some or all of their desired changes appear. There is a possibility of adoption after seeing some or all of their desired changes. Although their inaction, before seeing the desired conditions (see Table 2), does not add value to the growth of the solar market they do not expose explicitly a negative decision and action for their non-adoption. Thereby, they exhibit an unconfirmed negative decision and unconfirmed positive actions to adopt before seeing the desired conditions. Eighteen laypersons represented this customer segment. Both experts and laypersons argued that although most of the Finnish citizens remained environmentally concerned about saving the planet, economic consideration and other conditions seemed to be important for them to decide and to install/adopt solar energy technology. Arguably, as such, a 42-year-old non-adopter laywoman mentioned:

> I would say probably, it may be the cost, and, then maybe just a lack of information. People always look what they get back from an investment because in every investment you first need to put some money and hopefully, you get some benefits.

4.3. Determination of patterns of social acceptance

According to most of the respondents the patterns of WTA- and social acceptance of solar energy among Finnish citizens could vary from urban to rural locations, from less cold places to more cold places, from locations close to the electricity grid to remote places, and most importantly from places where solar installations were visible or exhibited to places where they were not. In this regard, Finnish people's WTA solar energy in summer-cottages was the most-commonly stated opinion among respondents, as also found by [10,37]. In colder places like Lapland, people would rarely think of solar energy compared with those living in Helsinki. Furthermore, even in the same culture, for example in Eko-Viikki, it was observed that some enthusiastic and willing people had already installed solar panels, while some laypersons objected to and labelled such installations just a fashion and a hobby. According to the respondents, most Finnish citizens favour solar energy, as also seen by [6,7]. Furthermore, the expert respondents added that now it would be necessary to drive public intention into actions – behavioural change studies were viewed as crucial to undertake. As such, one expert said:

> It is not just about money and public support, it is really about whether the government would give any acceptance to solar energy. Now it is about an ambivalent opinion: the government thinks ok, solar is good, but it does not pay anything. People think, ok, it cannot be good because the government does not do anything. These are very much social issues.

Looking at different types of customer segments (see Fig. 2), the data seem to advocate three key patterns of social acceptance. Based on the description of the 'activated WTA adopters' and the literature on social acceptance, it is confirmed that they would belong to the actual adoption pattern represented by three laypersons. Most of the respondents argued that the rate of solar energy adoption was very low because the Finnish solar market was just in its initial stage of growth. They believed that the market share would increase soon, as also found by [14]. One expert respondent, who confirmed his adoption status, stated that commercially it was not beneficial for individual adopters to sell surplus solar electricity to the grid since the economic return was much lower than from the general grid-based electricity. He further added that it was suitable for enthusiastic adopters and for personal consumption. Although none of the adopter respondents was a rejector or fell into an opposition category, the expert respondents asserted that such a change could happen and they mentioned some relevant post-

adoption conditions (see Table 2).

The three categories of customer segment, namely the 'unconditional WTA would-be adopters', 'conditional WTA would-be adopters', and 'conditional WTA non-adopters', fall into the acceptance in principle pattern of social acceptance (see Section 2.5). Based on the findings of the study, the acceptance in principle concept could be defined as a state among people in which they are unaware, undecided and/or decided but have not confirmed adoption due to some unsatisfied conditions mentioned earlier (see Table 2). As such, the 'acceptance in principle' pattern was observed among the highest number (21) of laypersons.

The 'non-WTA non-adopters' customer segment includes 'rejection' and 'opposition' patterns of social acceptance. One layman, who rejected, informed that he had clear knowledge about the unsuitable Finnish weather conditions for solar energy and he considered that it would be an unwise cost of a lot of money to invest in solar energy. Thereby, his condition validates Rogers's [44] explanation of the rejection concept (see Section 2.5). One female expert showed her opposition to adopt solar energy by stating that she did not find any logic for investing in solar energy in Finnish weather conditions. She added that it was not compulsory to emphasize every source of clean energy, rather insisting on focusing only on the proven and efficient renewable energy sources. So, her status mostly corroborates the concept of 'opposition'.

Most of the respondents emphasized the pre-adoption factors/conditions. Those factors/conditions have been explained in different terms: unconditional and conditional willingness states of WTA (Section 4.1); 'unconditional WTA would-be adopters', 'conditional WTA would-be adopters' and 'conditional WTA non-adopters' (Section 4.2); and the acceptance in principle pattern of social acceptance (Section 4.3). Respondents emphasized the pre-adoption factors/conditions that need to be considered seriously for the diffusion of solar energy adoption in Finland. Post-adoption factors/conditions in terms of maintenance, engagement, and feeling of ownership, referring others (word of mouth) and continuation of the adoption were also emphasized. Most of the experts stated that solar energy would not require much post-installation maintenance work, as also discussed by [66]. However, among a few laypersons, there was confusion about maintenance, since they had heard about the lack of maintenance in some of the solar integrated blocks of flats in Eko-Viikki. The 'activated willingness' state of WTA, 'activated WTA adopters' and 'adoption' points include post-adoption factors/conditions in this study. Mostly the experts rather than the laypersons mentioned rejection and opposition patterns as a mixture of both pre-adoption and post-adoption factors/conditions. A significant number of respondents mentioned that post-adoption actions might be positive or negative. However, most of the experts and laypersons stated that they did not hear about any public complaint related to solar energy. Furthermore, the rejection- or opposition-related points mentioned in terms of the 'unwillingness' state of WTA, 'non-WTA non-adopters' and 'rejection' and 'opposition' in Sections 4.1, 4.2 and 4.3 respectively are important to consider in terms of policy recommendations.

5. Conclusions and recommendations

This study mainly set out to explore public WTA solar energy by answering three research questions on states of WTA, categories of customer segments, and related patterns of social acceptance. In answer to the first research question, four states of WTA namely activated willingness, unconditional willingness, conditional willingness, and unwillingness were found. They formed four quadrants of WTA. Furthermore, they were seen to include all forms of customers in terms of their adoption status and opinions. In answer to the second research question, five categories of customer segments as an outcome of those WTA states were found: activated WTA adopters, unconditional WTA would-be adopters, conditional WTA would-be adopters, conditional WTA non-adopters and non-WTA non-adopters. This was also supported by the status and opinions of the respondents. Those five categories of WTA state-based customer segments determined and corresponded to three patterns of social acceptance: adoption, acceptance in principle, and rejection. Opposition was also observed as a stronger form of rejection because at that time the respondent not only rejected but also opposed solar energy. Notwithstanding the piecemeal rejection and opposition, the respondents argued that most of the green-loving Finnish citizens would fall into the 'acceptance in principle' category.

Clear indications about the existence of different states of WTA were found. It was also seen that such states of WTA also directed the confirmation of decision and actions related to adoption, forming customer segments with different patterns of social acceptance. This followed observation of the respondents' personal and contextual conditions and their opinion about others.

This study suggests that the diffusion of solar energy could be enhanced even without changing the present support structure in Finland if the stated customer segments are approached properly with adequate information related to cost - benefit, support schemes, and business models. For instance, in every building area, there is a housing association and the owners meet mainly annually to discuss different issues. Concerned authorities (e.g. municipalities) could pass on appropriate information for those meetings, which could be disseminated to the attendees and non-attending owners. Continuous follow-up would also help. Furthermore, it could also change the mindset of other customer segments towards adoption because there is always more or less an emulation tendency among people in the community to follow others in such cases (see also [13,39,42,43]). This would accelerate adoption by a considerable number of 'unconditional WTA would-be adopters'. The turn-key model, for instance, takes the responsibility to plan and set up solar power systems, arrange generation equipment and grid connection and offers the possibility to sell surplus power to the utility. This may push the 'unconditional WTA would-be adopters' to adopt without much delay. The joint purchase model offering cost-effective and easier purchase may also attract many in the community to adopt. By having appropriate information and seeing adoption actions of the 'unconditional WTA would-be adopters' many of the 'conditional WTA would-be adopters' could start to adopt solar energy. Furthermore, many of the 'conditional WTA would-be adopters' and 'conditional WTA non-adopters' could think of passive adoption of solar energy without being involved in practical installation actions by seeing the existing adopters and having a clear idea about the 'utility-side solar PV' business model that has already been launched by Helen. An adoption boom at the individual level would be accelerated if some support (e.g. capital investment support, feed-in-tariff) were allocated. Non-owners of apartments or houses could be interested in passive adoption if they have proper information. So, it is also important to disseminate appropriate information to all households in the community so that the rate of adoption could be accelerated even without making any change to the current support structure.

Likewise, through municipalities contacting different housing associations, a broader picture of customer segmentation could be gained and, based on their states of WTA, necessary steps could be taken to accelerate the solar market. In this way, not only the affluent (e.g. for individual installation) but also the low income (e.g. for passive adoption through the 'utility-side solar PV' business model) green-loving Finns could be included in the adoption process.

This study thereby indicates that segmenting customers based on their WTA states could increase the rate of adoption if addressed with the stated supportive focus. Attention was drawn by the respondents to the need to address different conditions and related solutions to improve the solar market in the country. If factors/conditions related to conditional WTA and non-WTA are left unaddressed, it will continually inhibit the functioning of the solar market in particular and the renewable energy market in general.

This article identifies various states of WTA, customer segmentation

based on those WTA states and their position in the patterns of social acceptance as the result of different personal and contextual factors. Although WTA traditionally has been interpreted positively (willingness) or negatively (unwillingness), this article unravels public WTA into four states. It also links different personal and contextual conditions to those states of public WTA. By segmenting customers based on those states of WTA, this article makes it clear that to attract maximum customers it is unwise to focus only on the unconditional WTA by disregarding other customer segments. An urge to fill the pipeline of customer acquisition by pulling (i.e. attracting people through various benefits, support schemes, services) and pushing (i.e. role of adopters on their peers, information sharing and feedback generating actions at the community level) people to the subsequent adopter group is expressed. In that sense, without being restricted to solar energy or other renewable energy markets the stated customer segments may also attract multi-disciplinary interest where business and customer related aspects are pivotal.

Studying public WTA solar energy gives hints about public readiness to adopt solar energy and its prospects, but it can be studied further in terms of locating existing routes to the adoption of solar energy, which can be different based on individual preference, and different offers to potential customers. Future research could include a larger sample to replicate the states of WTA, the categories of customer segments, and the related patterns of social acceptance so that more detailed insights can be generated. Inherently, this study also observed a form of intention- behaviour gap in the adoption of solar energy among Finnish citizens. This also warrants attention in future research.

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Appendix A. Use of human-centred approaches to adopt solar energy in some Finnish studies

Study	Dataset, methods and sources	Respondents and sample size	Inclusion of solar energy
[5]	1st phase: Quantitative using advanced energy system analysis computer model (EnergyPLAN)	1st phase: 3 weeks of hourly measures of demand, supply and storage of electricity, grid-based gas and district heating	Direct (solar photovoltaics and energy storage)
	2nd phase: survey (qualitative interviews as evident in the findings)	2nd phase: people from the Finnish Local Renewable Energy Association (experts) and active Finns interested in energy transition movement (31)	
[17]	1st phase: semi-structured interviews with respondents	1st phase: households participated in joint acquisition and two representatives of local energy company (total 12)	Direct (joint purchasing of solar panels)
	2nd phase: Four workshops (presentations, field notes, e-mail correspondence and workshop report generated data)	2nd phase: 15 prosumer attendees	
[9]	1st phase: SITRA (Finnish Innovation Fund) project funded documents and media coverage analysis, and interview	1st phase: main champion (1)	Direct (demonstration projects of solar building integration)
	2nd phase: literature review, media coverage analysis, interview	2nd phase: key players (2)	
	3rd phase: project reports, media coverage analysis, interview	3rd phase: main champion (1)	
[35]	1st phase: analysis of official Finnish government documents on climate and energy strategy	1st phase: documents from the years 2008 and 2013	Direct (solar energy policy and potential in Finland)
	2nd phase: semi-structured interviews	2nd phase: Finnish members of parliament (3), industry representatives (3), civil servants (3), representatives of corporations and companies in the solar energy business (5), solar energy associations (2) and representatives of environmental non-governmental organizations (3)	
[11]	1st phase: scale-based evaluation questionnaire (quantitative)	1st phase: expert panel in distributed energy value chain (17 face-to-face and 9 online interviews)	Indirect (discussion of solar energy in association with heat pumps, biogas combined heat and power plants in terms of electricity and heat energy)
	2nd phase: semi-structured interviews	2nd phase: project leader (1), senior managers of energy companies (9), energy association representatives (4), advisers to the government (2) and energy economics researchers (1)	
[36]	1st phase: field-notes,	1st phase: 100 presentations and 200 studies	Direct (discussion of solar energy through field-configuring events)
	2nd phase: interviews	2nd phase: representatives of technology companies, SITRA (Finnish Innovation Fund), Association for Renewable Energy, and scientific establishments	
	3rd phase: archival data	3rd phase: Six formal documents from intermediaries, conference programmes, participants list, and 15 media articles	
[37]	1st phase: Internet-based (seven-point Likert-scale based research and screening method)	1st phase: Internet-based energy technology forums (3)	Indirect (solar energy discussed in association with other renewable energy technologies)
	2nd phase: interviews	2nd phase: male (12) and female (4) consisting of non-professionals with no involvement in commercial residential energy technology, users of renewable energy technologies and those who acquired such technology one year ago.	

[66]	1st phase: semi-structured interviews	1st phase: senior executives (3), entrepreneurs (5), R&D directors (3), researchers (4), policymakers (11), consultants (2) and a public relations manager	Indirect (solar energy discussed in association with life sciences/ biotechnology)
	2nd phase: workshops	2nd phase: representatives of Finnish life sciences community (29)	
[64]	1st phase: thematic consumer interview	1st phase: male (5) and female (5) teachers and librarians in Helsinki metropolitan area	Indirect (solar energy discussed as a part of different green electricity sources)
	2nd phase: interviews	2nd phase: key people involved in energy sectors (25)	

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