Identifying consumer psychological empowerment compensation mechanisms in the context of photovoltaics: a tetraclass model approach.

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Abstract:

Solar photovoltaics (PV) literature has strived to understand predictors and model the behavior of consumers regarding PV adoption or rejection. However, research paid relatively limited attention to what happens regarding consumers' satisfaction after installation of PVs, while PV deployment has been hit by a significant slowdown in EU. Still, PV adoption studies have outlined many benefits of residential PV use that can be related to individuals' psychological empowerment facets, an antecedent of satisfaction. This multidimensional construct encompasses the beliefs individuals have regarding the meaning, their competence, autonomy, and the outcomes that their activities have on themselves and their community. In the last decade, scholars have also started to investigate the dark side of incentive policies on consumer behavior, but no investigated yet the impact of policies on consumer self-determination, a facet of psychological empowerment. Drawing on psychological empowerment theory, the purpose of this article is to explore and compare the structure of empowerment facets related to the use of PV when self-determination is restricted, so as to identify empowerment compensation mechanisms to restore satisfaction. For that purpose, we applied the tetraclass model approach, which establishes distinctive types of contribution to satisfaction in a four-point typology. Using a sample of 500 PV owners in France and Germany, we compared how PV use psychological empowerment manifestations fit into this typology when individuals perceive different levels of self-determination (SD) to use the technology, so as to compare the structure of psychological empowerment contribution to satisfaction when SD is eroded. We found that the impact manifestations associated to PV use exhibit higher levels of importance when SD is threatened by local policies or social pressure, so as to restore individuals' satisfaction. A deeper understanding of households psychological empowerment compensation mechanisms might reduce the deceleration in PV diffusion in European countries.

Keywords: empowerment; satisfaction; compensation; energy transition

1. Introduction

Transitioning the European energy system towards solar photovoltaic is critical to reducing global CO2 emissions. However, after years of stellar growth, the EU solar sector has been hit by a significant deployment slowdown, tumbling from 53% growth in 2023 to 4% in 2024[1]. Differences in the pace of individuals PV adoption also exist between regions, since governments have been applying specific incentive mechanisms to promote deployment. One characteristic of much of the solar PV literature is that it has strived to understand predictors and model the behavior of consumers regarding PV adoption or rejection (Alipour et al., 2021). However, research paid relatively limited attention to what happens regarding consumers' satisfaction after installation of PVs. Moreover, scholars didn't give much consideration to the impact of incentive policies on consumer behavior. Psychological empowerment theory proves particularly fruitful to investigate satisfaction regarding PV since in recent marketing research, scholars have emphasized that psychological empowerment, an antecedent of satisfaction (Pranic & Roehl, 2012; Auh, et al, 2019), can emerge through technology use as far as the artefact involves a particular pattern of consumer resources (Hanson & Yuan, 2018; Schweitzer & Simon, 2021). Besides, several PV adoption factors found in the literature can be considered as facets of individuals' psychological empowerment, a construct which encompasses beliefs that individuals have regarding four dimensions of an activity: meaning, competence, SD, and impact (Menon, 2001; Spreitzer, 1995). Indeed, individuals might perceive the activity of using PV as a way to reach energy transition contribution goals, or to reduce energy consumption bills, and hence feel empowered. In the meantime, the political pressure to install PV might decrease consumers SD who might feel disempowered. But so far, empowerment studies have not investigated the existence of consumers' psychological empowerment compensation when one dimension is threatened, as a way to restore one's satisfaction. Therefore, the goal of this work is to clarify empowerment factors associated with PV use that contribute to consumer satisfaction, and to examine how the structure of these factors is shifted when consumer SD is threatened.

To study these compensation mechanisms, our methodological approach is exploratory. It consists of the identification of consumers' empowerment facets related to PV use, and the comparison of the structure of these facets as contributors to satisfaction between two groups with different levels of SD. To that aim, we use the tetraclass methodology (Llosa, 1996) to assess distinctive types of contribution to consumer satisfaction for the groups which are compared.

[1)] https://www.solarpowereurope.org/insights/outlooks/eu-market-outlook-for-solar-power-2024-2028/detail#foreword-executive-summary

2. Theoretical Background

2.1 Conceptual view of satisfaction

Consumer satisfaction has been defined and measured in different ways over the years (Oliver, 2010). In this research, we refer to the definition given by Garbarino and Johnson (1999) who consider it « a post-purchase immediate evaluative judgment or an affective reaction towards the transaction with the most recent firm ». To measure satisfaction, several models such as SERVQUAL (Parasuraman et al., 1985) implicitly assume a linear relationship between service quality elements and satisfaction. However, other authors consider that the quality elements of a service have asymmetric impacts on satisfaction and dissatisfaction (Lichtlé et al., 2002; Llosa, 1996). More specifically, Llosa (1996) demonstrated proposed a tetraclass model where elements are classified into 1 of 4 categories, according to the way in which they affect consumers' experiences. (1) Basic elements contribute strongly to the clients' overall level of dissatisfaction when they are evaluated in an unfavorable way. However, when they are evaluated favorably, they contribute only weakly to client satisfaction; (2) Plus elements contribute strongly to the overall level of client satisfaction when they are evaluated favorably. When they are evaluated unfavorably, they contribute weakly to the client's dissatisfaction; (3) Key elements contribute strongly to the degree of dissatisfaction or satisfaction of the client, regardless of the type of evaluation by the client; (4) Secondary elements: do not have a primary role in the level of overall client satisfaction or dissatisfaction, whichever way they are evaluated. Bartikowski and Llosa (2001) favor the tetraclass model to measure satisfaction. Among others, they outline that the weighting of elements depends on the services' positive or negative performance, that the tetra-class model is based on clients' own experiences and not on a simulation, and is finally more robust.

2.2 Conceptual view of power in technology use: psychological empowerment

Psychological empowerment integrates "perceptions of personal control, a proactive approach to life, and a critical understanding of the sociopolitical environment" (Zimmerman, 1995, p. 581), and is thus described as a multidimensional construct by empowerment theorists (Zimmerman, 2000). Specifically, Spreitzer (1995) defines psychological empowerment as a psychological state of enabling related to a task that manifests in four cognitions: meaning, competence, SD, and impact. Meaning refers to the alignment between the goals of the tasks and an individual's values and internalized norms. Competence is an individual's belief in his or her capability to perform tasks with skill. SD reflects an

individual's sense of choice regarding the initiation and regulation of their actions. Impact is an individual's belief that he or she can influence outcomes related to the specific tasks. In terms of consequences, psychological empowerment has been found to enhance individuals' satisfaction regarding a set of tasks (Pranic & Roehl, 2012; Auh, Menguc, Katsikeas, & Jung, 2019). In recent marketing research, the discussion of consumer psychological empowerment for performing tasks using technologies has emerged, which can be applied to the level of every digital device as far as the device involves a particular pattern of consumer resources (Hanson & Yuan, 2018; Schweitzer & Simon, 2021). However, most empowerment studies are not considering potential ambivalence between dimensions (for an exception, see Schweitzer & Simon, 2021), and thus have not investigated the existence of customer's compensation when one dimension of empowerment is threatened, as a way to restore one's satisfaction.

2.3 PV use & psychological empowerment

Recent literature on PV use has highlighted various contributors to consumer adoption, and some of which might be assimilated to empowerment facets of an activity. For instance, several authors outlined the importance of equipment quality and performance in terms of lifestyle quality (Komatsu et al., 2013; Siwiec & Pacana, 2021), contribution to energy transition (Komatsu et al., 2013) and money savings (Bauner & Crago, 2015; Briguglio & Formosa, 2017), referring to the dimension of impact of psychological empowerment. Moreover, other authors such as Briguglio & Formosa (2017) revealed that meanings associated to PV use such as pro-government feelings and the idea of contributing to the preservation of resources were determinants of PV adoption.

Meanwhile, literature has started to investigate the dark side of public incentive support (Bunea et al, 2020) and potential negative feedback processes shaped by political contexts (Ayoub & Geels, 2024) on consumer behavior regarding PV. No research to date has investigated the impact of political incentives on consumers SD, even though pressure on consumers impedes individuals' sense of choice regarding the initiation of their actions. These ambivalent empowerment facets regarding PV use invite us to investigate the existence of compensation mechanisms between dimensions, as suggested by Schweitzer & Simon (2021).

3. Methodology: data collection and analysis

We applied the tetraclass approach (Llosa, 1996). For our research question, we specifically compared how psychological empowerment elements related to PV use fit into

the four-level typology of Llosa (1996) when individuals perceive different levels of SD, to compare the structure of contribution to satisfaction. To increase the variation in SD levels in relation to PV use, this study was conducted in both France and Germany. The use of perceptual maps in the tetraclass method made it possible to show the contribution of each psychological empowerment element to the feeling of overall satisfaction, depending on the level of perceived SD in the use of PVs, which facilitated the comparison between groups.

In accordance with other studies in the field (e.g. Llosa, 1996; Robinot & Giannelloni, 2010), qualitative and quantitative tools were used in a complementary way. First, a list of elements that contribute to overall satisfaction with PV was elicited by means of 35 exploratory face-to-face interviews with French (15) and German (20) households and analyzed through thematic analysis. The interview data were complemented with a netnography of 69 opinions collected from solar panels' owners analyzed by the mean of a lexical analysis. Finally, the triangulation of all qualitative data enabled to generate 33 elements contributing to PV satisfaction considered as facets of psychological empowerment (Appendix A). These elements were included in a common questionnaire for France and Germany, which consisted of a satisfaction evaluation of all items on a five-point Likert scale ranging from strongly disagree (1) to strongly agree (5), an overall customer satisfaction measure, an evaluation of the perceived self-determination level regarding the use of PV, and demographical features. Panel companies were used to send the questionnaire to reach 250 (FRA) and 260 PV owners (GER).

In terms of data analysis, compiling the data of both countries, we first considered elements as first order reflective measures of psychological empowerment dimensions. For each dimension of empowerment, only the most representative items were selected (see Appendix B, Table 1). To assess the internal validity of the constructs, a confirmatory factor analysis was performed on the four-factor solution using PLSPM on Xlstat. The tests confirm the reliability of the constructs (Cronbach's alphas for all constructs are at acceptable levels: $\alpha > 0.6$), the convergent validity (rho >0.82) and the discriminant validity (see Appendix C, Table 2). Then, we created two perceived SD groups to compare. A split was used on the SD scores in order to develop the groups: the low SD group (G1) composed of 189 PV owners (scores between 1 and 3,9), and the high SD group gathering 321 PV owners (scores above 4). To build the tetraclass model, we reproduced the classification technique of Llosa (1996). The measures of satisfaction and perceptions about attributes were dichotomized in order to construct a table of contingency. The table was composed of the overall satisfaction index split into two modalities. The cutoff point for the two modalities is the overall satisfaction

dichotomized in a negative modality (1,2,3) and in a positive modality (4,5), in line with the frameworks of Lichtlé et al. (2002) and Llosa (1996). Attribute perception scores were also dichotomized with the same method. A factorial correspondence analysis was then applied on these two variables. The analysis generated two coordinates for each attribute, where the first of these coordinates corresponds to the attribute contribution to satisfaction when negatively evaluated (X-coordinate), and the second one (Y-coordinate) to the attribute contribution when positively evaluated (Llosa, 1996). Based on these scores, the mapping was elaborated.

4. Results

The results are first presented for the PV owners low in SD (G1), then for the highly self-determined group (G2). Concerning G1 (see Appendix D, Figure 2), two contribution weights described by Llosa (1997, 1999) are present. First, using the terminology of Llosa, we observe 4 *basic* attributes which strongly contribute to dissatisfaction whereas they only slightly contribute to satisfaction. Three of them reflect the psychological impact, which refers to the possibility of making a difference and influencing outcomes when using PV (performance, energy safety and environmentally friendly). The last element (aesthetics) relates to the meaning associated with PV use, in this case the perception that the technology allows the fulfillment of a desired aesthetics value. Second, 11 attributes are *plus*, which strongly contributes to satisfaction when they are positively evaluated. These attributes correspond to the psychological impact elements when using PV (i.e. rising prices protection, weather resistance, economy savings, etc…), but also to competence (customer service, ease of use…), and meaning (contribution to sustainability, to environment.).

Concerning the G2 (see Appendix E, Figure 3), only one contribution weight have been found (*plus*). Thus, among the 15 PV use attributes, 4 do not have the same contribution weight to individuals satisfaction across the two groups, whereas 9 have the same weight (see Appendix D, Table 3). Among these 4 non-stable attributes, all are *plus* elements which become *basic* when individuals are less self-determined to use PV. Moreover, most of these attributes refer to the psychological impact elements (except aesthetics).

5. Implications

Our work introduces psychological empowerment facets related to PV use, and their contribution weight to satisfaction. Importantly, it suggests the existence of compensation mechanisms when one dimension of empowerment is threatened; more specifically,

psychological impact facets become *basic* contributors to satisfaction when SD levels are low, while they are *plus* contributors when individuals were self-determined in the use of PV.

The first contribution of this study is to extend existing scholarship on the impact of deployment policies on consumer behavior by exploring psychological impact consequences when self-determination to use PV is threatened. When compared with past recent research on the impact of policies on energy transition deployment (Bunea et al., 2020; Ayoub & Geels, 2024), our research provides a detailed and managerially actionable framework for designing effective PV and communication strategies. Second, we extend research on psychological empowerment in the use of a technology by detailing empowerment compensation mechanisms to restore satisfaction when consumers are pressured to use a device. While previous research exists on psychological empowerment perceptions in the use of a technology (e.g. Hartmann, Apaolaza & D'Souza, 2018; Wittkowski et al., 2020), our study offers an opportunity to understand how political pressure affects specifically impact facets of a device.

6. Limitations and future research

Our work also has some limitations. First, the study was based on a sample that was chosen for convenience; no attempt was made to determine whether the sample was representative of the PV owner population. Second, we didn't conduct an analysis of possible differences in the judgments of segments; for example, the categorization of an attribute in the matrix might depend on the gender, age or type of house of the solar panel owner.

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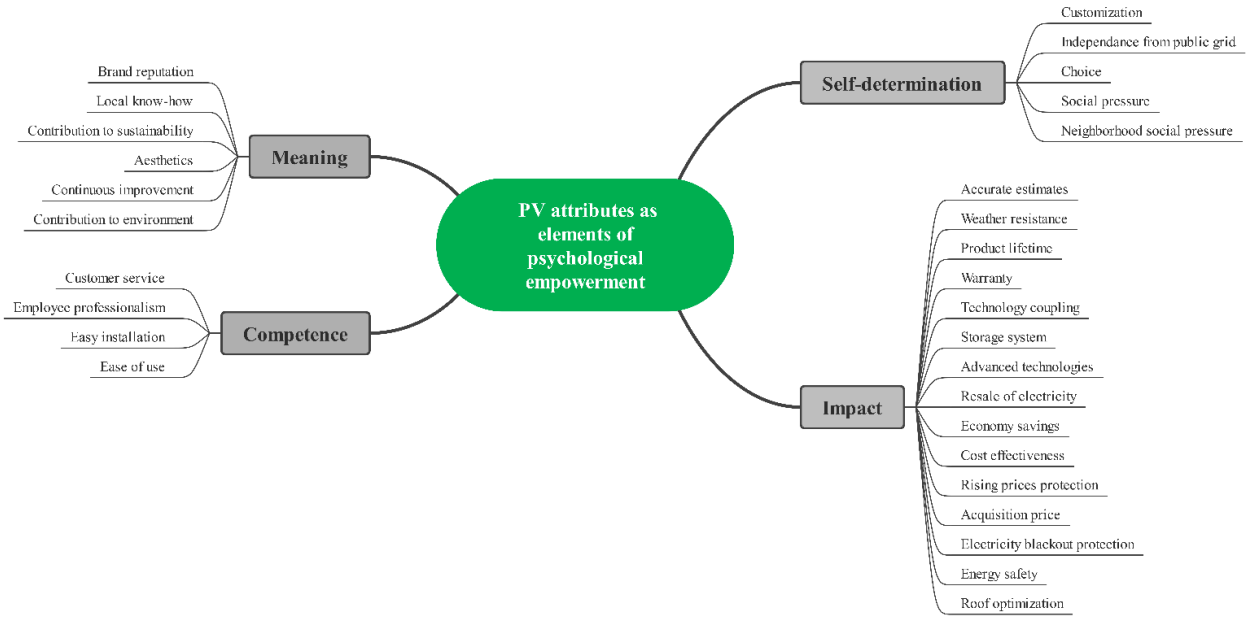
Appendix A : Figure 1. Results of the qualitative part of the tetraclass methodology :PV use elements contributing to satisfaction classified as psychological empowerment manifestations



Appendix B : Table 1. Items retained to measure psychological empowerment dimensions influencing satisfaction, factor loading, and Cronbach's alpha.

Construct	Items	Factor loading	Cronbach's alpha
Meaning	You appreciate the aesthetics of photovoltaic panels installed on your roof.	0.652	0.661
	With the purchase of photovoltaic panels, you feel you're contributing to sustainable development.	0,846	
	If more households get photovoltaic panels, environmental quality will improve.	0,815	
Competence	The company's employees demonstrated a high level of professionalism throughout the entire process, from the sale to the installation of the photovoltaic panels.	0,868	0.795
	Customer service was available and reassuring throughout your experience.	0,860	
	I experienced no difficulties during the installation	0,699	
	You like the ease of use and operation of photovoltaic panels.	0,710	
Self-determination	I have significant autonomy in determining how to use solar panels	0,872	0.868
	I can decide myself how to use my solar panels	0,909	
	I have considerable opportunity for independence and freedom in how I use my solar panels	0,886	
Impact	The photovoltaic panels you've installed are weather- resistant.	0,708	0.840
	Your photovoltaic panels offer a long service life.	0.728	
	You appreciate that your photovoltaic panels benefit from a guarantee covering several aspects (e.g. deterioration).	0,675	
	Photovoltaic panels can save money and reduce your electricity bills.	0,780	
	Using photovoltaic panels helps protect my family from rising electricity prices in the future.	0,779	
	Using photovoltaic panels enhances my energy safety.	0,674	
	When choosing my photovoltaic system, I opted for the system that would provide the maximum performance.	0,578	
	When choosing my photovoltaic system, I opted for the most environmentally friendly alternative.	0,542	
Satisfaction	I am satisfied with my overall experience with the manufacturer/installer.	0,786	0.824
	Photovoltaic panels are up to my requirements.	0,819	
	I recommend installing photovoltaic panels to my friends and family.	0,805	

Construct	Items	Factor loading	Cronbach's alpha
	If I were in the situation to buy a photovoltaic system again today, I would do it.	0,824	

Appendix C : Table 2. Confirmatory factor analysis, reliability and validity tests

Composite reliability :

Variable latent	Dimensions	Alpha de Cronbach	**Rho de D.G. (ACP)**
Meaning	3	0,661	**0,817**
Competence	4	0,795	**0,868**
Impact	8	0,840	**0,878**
Self-determination	3	0,868	**0,919**
Satisfaction	4	0,824	**0,883**

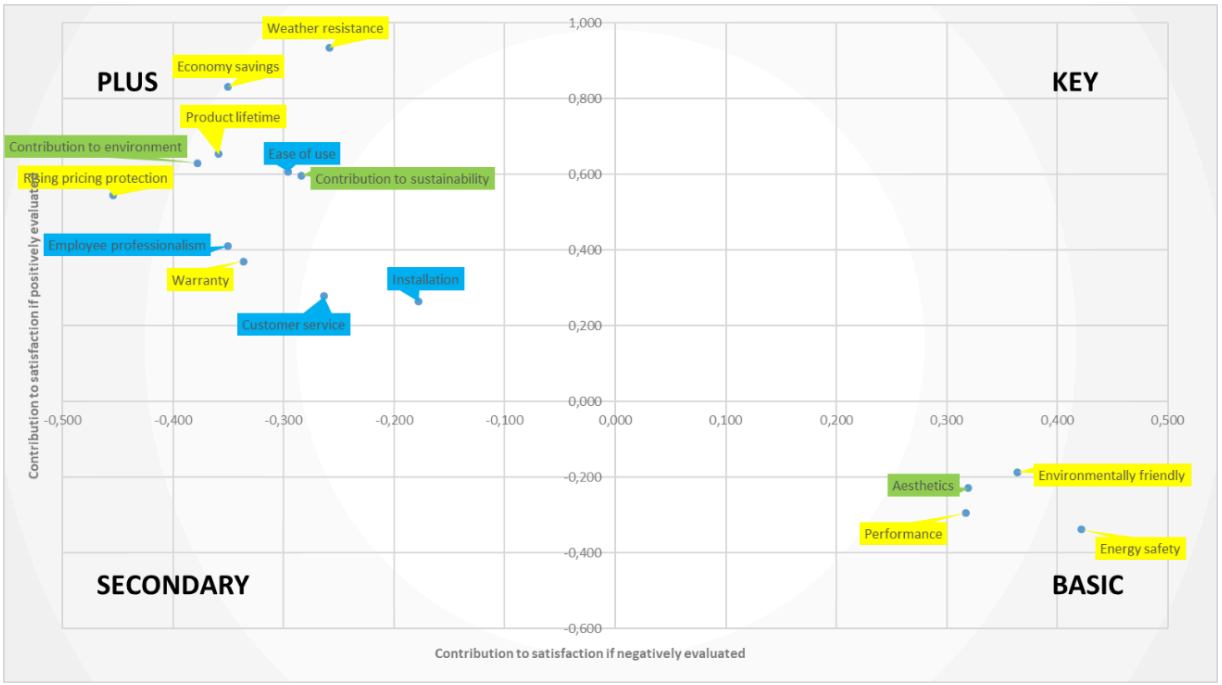
Cross-loadings :

	Meaning	Competence	Impact	Self-determination	Satisfaction
AESTHETICS	**0,652**	0,479	0,507	0,302	0,391
CONTRIBUTION_TO_SUSTAINABILITY	**0,846**	0,376	0,597	0,331	0,477
CONTRIBUTION_TO_ENVIRONMENT	**0,815**	0,306	0,532	0,314	0,408
EMPLOYEE_PROFESSIONALISM	0,401	**0,868**	0,535	0,372	0,556
CUSTOMER_SERVICE	0,388	**0,860**	0,522	0,349	0,531
INSTALLATION	0,309	**0,699**	0,406	0,283	0,354
EASE_OF_USE	0,446	**0,710**	0,652	0,450	0,532
WEATHER_RESISTANCE	0,414	0,557	**0,708**	0,378	0,480
PRODUCT_LIFETIME	0,459	0,559	**0,728**	0,384	0,479
WARRANTY	0,422	0,555	**0,675**	0,370	0,412
ECONOMY_SAVINGS	0,525	0,471	**0,780**	0,397	0,623
RISING_PRICES_PROTECTION	0,575	0,504	**0,779**	0,414	0,568
ENERGY_SAFETY	0,542	0,372	**0,674**	0,437	0,428
PERFORMANCE	0,405	0,406	**0,578**	0,287	0,342
ENVIRONMENTALLY_FRIENDLY	0,590	0,304	**0,542**	0,274	0,311
SELF-DETERMINATION 1	0,361	0,484	0,488	**0,872**	0,384
SELF-DETERMINATION 2	0,343	0,375	0,467	**0,909**	0,402
SELF-DETERMINATION 3	0,386	0,390	0,481	**0,886**	0,375
SATISFACTION 1	0,404	0,717	0,540	0,349	**0,786**
SATISFACTION 2	0,430	0,507	0,544	0,379	**0,819**
SATISFACTION 3	0,520	0,394	0,564	0,373	**0,805**
SATISFACTION 4	0,432	0,422	0,554	0,302	**0,824**

Square correlation
<AVE :

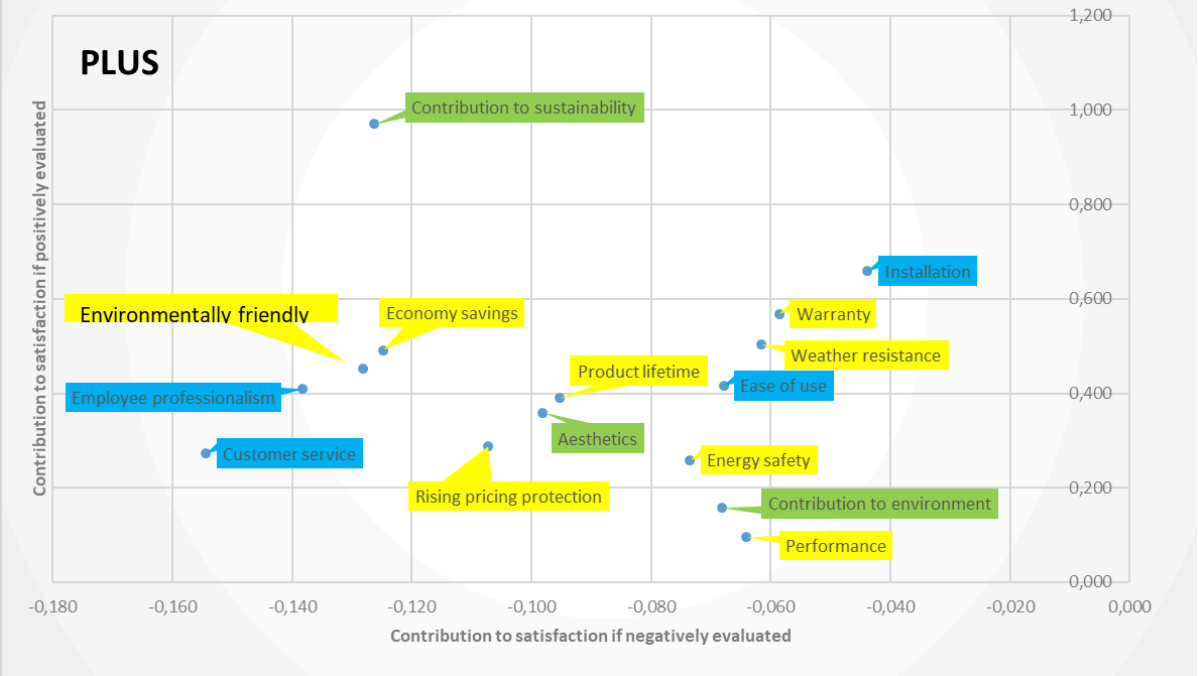
	Meaning	Competence	Impact	Self-determination	Satisfaction	Moyenne Communalités (AVE)
Meaning	**1**	0,246	0,499	0,166	0,305	0,602
Competence	0,246	**1**	0,463	0,219	0,408	0,621
Impact	0,499	0,463	**1**	0,289	0,464	0,473
Self-determination	0,166	0,219	0,289	**1**	0,189	0,791
Satisfaction	0,305	0,408	0,464	0,189	**1**	0,654
Moyenne Communalités (AVE)	0,602	0,621	0,473	0,791	0,654	**0**

Appendix D : Figure 2. Categorisation of psychological empowerment facets for low self-determined PV owners (G1)



Meaning facets
Competence facets
Impact facets

Appendix E : Figure 3. Categorisation of psychological empowerment facets for high self-determined PV owners (G2)



Meaning facets
Competence facets
Impact facets

Appendix D : Table 3. The PV use attributes variation among the two self-determined groups

PV Use attributes	*G1*	*G2*
Employee professionalism	*PLUS*	*PLUS*
Customer service	*PLUS*	*PLUS*
Aesthetics	***BASIC***	***PLUS***
Installation	*PLUS*	*PLUS*
Weather resistance	*PLUS*	*PLUS*
Product lifetime	*PLUS*	*PLUS*
Warranty	*PLUS*	*PLUS*
Ease of use	*PLUS*	*PLUS*
Contribution to sustainability	*PLUS*	*PLUS*
Economy savings	*PLUS*	*PLUS*
Rising prices protection	*PLUS*	*PLUS*
Economy savings	*PLUS*	*PLUS*
Contribution to environment	*PLUS*	*PLUS*
Performance	***BASIC***	***PLUS***
Environmentally friendly	***BASIC***	***PLUS***
Energy safety	***BASIC***	***PLUS***