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An examination of attributes and barriers to adopt biomass and solar technology. A cross-cultural approach

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JOURNAL OF ENVIRONMENTAL MANAGEMENT

Please, find attached an electronic copy titled "**An examination of attributes and barriers to adopt biomass and solar technology. A cross-cultural approach**" written by Elena Higueras-Castillo, Francisco Muñoz-Leiva and Francisco José Liébana-Cabanillas as a potential publication.

Kind Regards.

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Highlights

Comparative analysis on three countries: Spain, Germany and Mexico.

Anova tests confirm significant differences between countries.

Monetary investment and the changes at home are the main drawbacks.

Employment is a highly-valued attribute by the three populations.

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Abstract

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Keywords: Renewable energies, barrier, collectivism, adoption, cross-cultural.

1. Introduction.

The population's use of energy based on fossil fuels, such as oil and coal, makes the current growth model unsustainable. It is also worth noting the consequences that this deterioration entails for our planet, which are perceptible and manifest mainly through climate change. It is now known that humans triggered climate change, especially through the increase in power consumption and the high amount of waste it generates (García-Maroto, 2012). Problems such as global warming and air pollution are mainly caused by the combustion of solid, liquid and gas fuels during the production and use of energy (Jacobson, 2009). The scientific research also suggests that socially responsible consumers perceive ecological products more favorably (Laroche and Barbaro-Forleo, 2001). In this sense, new economic opportunities arise from the most common concerns about the environment, redefining business strategies. As a result, many companies are trying to develop products and processes that are both profitable and ecological (Epstein and Buhovac, 2014). However, in spite of this widespread support for organic products among consumers, power companies have not actually succeeded in their digital marketing campaigns (Peattie and Crane, 2005).

Sustainable development will enable economic growth, social progress, and a rational use of resources aiming to cover the current energy demand without compromising the supply for future generations (Armaroli and Balzani, 2007). To this end, the ideal solution would be to switch the focus of current energy models from traditional energies to renewable energies.

This research assesses consumers' perceptions of the main characteristics of renewable energy sources (biomass and solar) that influence their adoption. The study is focused on cultural differences in the adoption of clean energies between three regions with a different level of collectivism: Spain, Germany and Mexico. Furthermore, it examines pro-environmental behavior and New Ecological Paradigm (NEP) scale.

The literature review shows a research gap in this topic that this study fills. In this sense, the second section of the study analyzes the sector of renewable energies in the regions approached by this research and the countries selected as representatives: Spain, Germany, and Mexico. The third section is a review of the scientific literature which explores the variables studied. The fourth section explains the methodology applied in the study. The fifth section discusses the results of the descriptive data

analysis at the country level. Finally, the main conclusions, limitations and avenues for future research are discussed in the last section.

2. The renewable sector in numbers. The case of Spain, Germany, and Mexico.

The next section is a presentation of the Spanish, German and Mexican contexts, with a brief mention of the most relevant data and context of the renewable energy sector.

2.1. Spain

In comparison with other countries in Europe, renewable energies in Spain have had little impact despite having been promoted since the end of the 20th century by the different governments in power.

Since the renewable sector started to be promoted in the 90s, renewable energies have been steadily growing until 2014, when the sector reached a turning point. The statistics show that the renewable energy production achieved 74.907 GWh in 2014, which was 4.8% lower than in 2013. Renewable technologies reached an installed power of 32.850 MW in 2014, which compared to 2013 represents an increase of only 43 MW. Regarding the different technologies, wind power accounted for 68.1% of the total energy production, followed by photovoltaic solar power with 11%, small-scale hydropower with 9.4%, thermoelectric solar power with 6.6%, and biomass with 4.9%. In 2014, renewable energy sources supplied over 43% of the kilowatts generated in the Iberian Peninsula. However, there was a significant decrease in 2015 in the renewable energy share in the electricity system, particularly in the wind and hydraulic sectors. In addition, the installed renewable energy capacity was reduced: From 2012 to 2015 only 850 MW were installed in Spain, in contrast to the 6,800 MW installed in the previous years (APPA, 2014). According to the Spanish Energy Grid, renewable energies accounted for 37.1% of the overall power production in 2015. Secondly, nuclear power accounted for 21.9% of the overall power production.

Globally speaking, the renewable sector employed 70,750 people in 2014, which means a decrease of 24.3% since 2013. The technology of biofuels created more net jobs in 2014 than any other (895 employments), while the biomass for electricity production had the highest job loss rate, with 13,135 employments lost (APPA, 2014).

Considering the decline in market prices, the savings on fossil fuel imports and on CO_2 emissions, renewable energies have saved in the last decade €70,898 M to the entire Spanish energy system.

2.2. Germany

Germany proved that a developed industrial economy can move from a system based on nuclear energy and fossil fuels to an efficient renewable energy scheme. The renewable energy shares in this country grew from a production rate of 6% to almost 25% in barely 10 years. Solar panels and wind turbines are the main sources of renewable energy, as they increasingly supply up to half of the national electricity demand (Morris and Pehnt, 2012).

This energy transition is led by citizens and their communities. Individual activities at the personal and local level have enabled about 50% of the investment in renewable sources throughout Germany (Day Trading Academy, 2015).

Germany is considered an undeniable leader in renewable energies in Europe. No other country has proven such a commitment to clean energies. In particular, with wind power and photovoltaic solar power, Germany achieved an installed power of 33.73 GW and 35 GW respectively in 2014.

In 2015, renewable energies contributed with a total of 114,723 GWh during the first nine months of the year, which is 19.5% more than in 2014 and twice the nuclear power generated over the same period, according to the estimations of the German Association of Energy and Water Industries (BDEW). It is also estimated that 27% of the household electricity demand was covered by clean energies in 2014. This includes traditional hydroelectric power and methane (biomass), solar energy and wind power. The production of this type of energy has increased by 300% in Germany over the past decade (Day Trading Academy, 2015). Surprisingly, on 8th May 2016, a historic record was reached with a clean energy production which covered almost 90% of the overall demand, so that the price of electricity fell to negative levels and industrial consumers economically benefiting from the use of electricity (Planas, 2016).

2.3. Mexico

The 2013-2027 National Energy Strategy points out that, if no strong measures are taken to diversify the energy supply, Mexico is very likely to become a net importer of energy. For this reason, energy security has been acknowledged as a government priority.

In a context of scarcity of fossil resources, the Law on the Use of Renewable Energies and Financing for Energy Transition (2008), and the General Law on Climate Change in 2012 established as a goal for 2024 to generate at least 35% of the national electricity demand from non-fossil energies.

In 2013, within the overall energy produced (39,931 GWh) from renewable sources, 75% was hydroelectric, 14% geothermal and 8% wind power. In particular, considerable progress was made in the wind power industry, as it reached said percentage in barely 10 years (Studer, 2014)

The operational installed wind power capacity reached 1,289 MW in 2012, from which only 7% is operated by the Federal Energy Commission, while the rest is operated by concessionaires under plans of self-sufficiency, and by small and independent producers.

It is estimated that by 2028, the installed capacity for electricity generation from renewable sources will increase by 19,761 MW, from which, wind and hydraulic power are expected to have the largest share, with 59% and 21% respectively, followed by solar power with a 16% share.

Mexico is among the five most attractive countries in the world for investments in photovoltaic solar power projects, only behind China and Singapore. This is explained by the fact that the country is part of the "Sun Belt", with a daily radiation rate above 5 kWh per m^2. Likewise, Mexico has the largest manufacturing base for photovoltaic modules in Latin America. Therefore, many international companies consider Mexico to be an attractive destination for investments in this sector.

Finally, the Mexican market is large and appealing for this kind of investment, not only due to its huge potential in terms of wind, sun, geothermal, water and biomass resources, but also as an opportunity to manufacture equipment for the industry, to gain expertise in the equipment industry and also in terms of electricity production and distribution (ProMéxico, 2013).

Mexico produced 23% of its energy from renewable sources in 2014 and has ambitious goals for the future.

3. Scientific literature review

The key variables assessed in the analysis carried out in this study are: previous knowledge on renewable energies, consumer behavior toward environmental and pollution issues, environmental concern measured against the NEP scale, attitude toward household installations of biomass and solar energy, the intention to purchase these sources of energy, as well as the Geert Hofstede's approach to cultural differences. Lastly, a reference is also made to the cross-cultural approach adopted in this research.

3.1. Previous knowledge

Previous knowledge can be interpreted as the information that a certain person has on a particular matter, which enables this person to recognize certain opportunities (Shepherd and DeTienne, 2005). This way, the information available to an individual depends on their own personal experiences, which is why we should assume that information is not distributed proportionately among consumers (Shane and Venkataraman, 2000). Therefore, this information inequality between individuals explains that some of them identify certain opportunities, while other do not (Venkataraman, 1997).

People can acquire knowledge through their own experiences, third parties or through visual, verbal, and sensorial stimuli such as advertisements, journalistic texts, magazines or TV programs (Huang, 2014). Another way of attaining greater knowledge is through information searching (Bloch et al., 1986).

According to Brea and González (1990), a consumer will first of all use the knowledge already available when making a purchase, since this information processing is easier and more efficient. Likewise, well-informed consumers will pay more attention to the most relevant information and will search for information when they perceive the benefits of it.

On the other hand, within previous knowledge there is a difference between "subjective knowledge", which creates certainty about the information previously stored by an individual, "objective knowledge", which is the actual information that an individual has, and the own "experience" (Brucks, 1985).

Barber et al. (2014) state that objective knowledge about energy efficiency products can strongly help create attitudes towards that type of products.

Objective knowledge has been used in previous studies by researchers such as Maloney and Ward (1973) or Synodinos (1990), to conclude that higher levels of objective knowledge are not related to attitude. However, these studies took into consideration more ecological problems than the current study.

Subjective knowledge is a stronger motivation for purchase-related behaviours than objective knowledge (Feick et al., 1992). So, this study will measure our respondents' subjective knowledge about renewable energies, biomass and solar energy.

3.2. Environmental concern and pro-environmental behavior

"Environmental concern" is defined as the deliberate reduction of the negative impact an action can have on the environment. In addition, "pro-environmental behavior" as a "behavior consciously seeks to minimize the negative impact of one's actions on the natural and built world" (Kollmuss and Agyeman, 2002).

In this research, energy saving and activism are employed for explaining pro-environmental behavior (Fielding et al. (2008); Gatersleben et al. 2002; Poortinga et al. (2006); Senbel et al. 2014). Activism is defined by SGuin et al. (1998) as "the performance of specific behaviors", including conducts like belonging to an environmental group (Oskamp et al., 1991), committing to environmental protection behaviors (Syme et al. 1993), willfully adopting an eco-friendly behavior (Séguin et al., 1999) or collaborating with political actions in favor of the environment (Stern, 2000). Lubell et al. (2002) also defined it as an additional cost based on the value of contributing to the public good. On the other hand, energy savings are also used by researchers as an indicator of environment-friendly behavior (Gatersleben et al., 2002). These savings can be approached from two perspectives: from the direct and the indirect consumption. Direct energy consumption is related to the use of gas, electricity, and fuel for households, while indirect consumption is more related to the energy consumed for producing goods (Abrahamse and Steg, 2009).

Naturally, people adopt behaviors related to specific and logic facts in their daily lives, for instance, saving energy, purchasing environment-friendly products, or selecting a means of transport (Bamberg, 2003). If a customer acquires energy-saving light bulbs, it is likely that he or she turns off the lights when they're not in use; if someone buys ecological food, they are also likely to use a means of transport other than a car to travel, i.e., public transport (Thøgersen and Ölander, 2006). These pro-environmental behaviors have been observed in different countries and they can facilitate the transition to lifestyles that improve the environment. This can be carried

out by creating a sociocultural context that encourages citizens to take actions in order to safeguard the environment (Whitmars and O'Neill, 2010). From this perspective, pro-environmental behavior enables a new point of view, to conceptualize its causal role as both a direct and an indirect determinant of more specific environmental behaviors, like the purchase of renewable energy (Bamberg, 2003).

Going deeper into the New Ecological Paradigm (NEP), Dunlap and Van Liere (1978) proposed a 12-item scale, which has been adopted over time as a common and accepted measure of environmental concern by researchers. However, due to the use of this scale for determining beliefs, attitudes, and values, it can be confusing in the measurement of these attributes.

Dunlap et al. (2000) claim that this is because the scale items express primitive beliefs. According to Rokeach (1968), primitive beliefs define the internal core of the belief system, its basic truths about the reality and one's own nature. These primitive beliefs will intervene in the development of a great number of beliefs and attitudes regarding environmental issues. Some authors have integrated the NEP scale in their models as a measure of primitive beliefs (Gray and Weigel, 1985; Stern et al., 1995). This type of beliefs would also trigger an impact on behavior, although chances and obstacles hinder the possibility of a relationship between the NEP scale and ecological behavior (Gardner and Stern, 1996).

Another particularity of the NEP scale is that in most studies it results in a variable number of factors, even though it was designed for measuring a single construct. Although the idea of paradigm entails a certain consistency level, it is advisable to confirm its lower structure through a factorial analysis. This way, one can decide whether to use it as a single variable or as several variables, creating subscales.

A revised version of the NEP scale (Dunlap et al., 2000) has been recently introduced, known as the New Ecological Paradigm or Revised NEP scale. It is composed of 15 items and it was introduced as a renewed tool for three reasons: (1) it includes in a more comprehensive way the different aspects of an ecological vision of the world; (2) it balances out the number of pro and anti-NEP items; and (3) it updates the terminology of the first version. Apart from the three topics covered in the classic scale, this new version includes items associated with the anthropocentric idea of the exceptional human nature, i.e., the idea that humans are an exception to the laws of Nature, as well as with the possibility of an ecological crisis caused by

climate change, induced by human activity. This new scale includes an index of slightly greater internal consistency than the previous studies, and it retains the dimensionality issue.

In their study, Sanz and Guillén (2005) presented a Spanish version of the revised NEP scale, which this research approaches.

3.3. Attitude and predisposition to renewable energies

Literature indicates that consumer attitude is one of the most important indicators in the decision-making processes related to the purchase of renewable energies (García-Maroto et al., 2015).

Research conducted on the attitude toward renewable energies reveal a widespread support with regard to these sources of energy in Europe (Sengers et al., 2010).

Some studies show that attitudes toward renewable energies are born from the concern about the role of fossil fuels in climate change. For instance, Poortinga et al. (2006) found a high level of consumer support in the decision-making process related to the type of energy consumed, pointing out that these decisions are motivated by the protection of the environment.

In this sense, Pfeifer (2003) also noted that the personal experience of direct observation of the environmental destruction has a long-lasting impact on awareness. Those who have witnessed natural disasters during their youth, such as storms or others, are more likely to protect the environment. Others believe that the government has the moral obligation of solving the environmental problems, regardless of the originator. In general, German respondents expressed a high level of awareness toward environmental problems. The topic of nuclear energy was rather controversial in Germany and most of respondents expressed strong view on this issue.

On the other hand, as explained above in the case of the study conducted in Murcia, this research found articles analyzing the attitude of individuals willing to pay more for consuming renewable energy.

Ek (2005) identified that, in the first instance, only 1% of the consumers did actually pay more for consuming renewable energy, while the attitude displayed toward this type of energy seemed much more favorable, between 40% and 90%. The explanation they found for this difference was that there is a higher number of factors determining the attitudes regarding the will to pay more for renewable energies.

The strong relationship between attitude and intention is supported in many research fields (Chan et al., 2010), though less supported in the environmental field. This theory has been applied only to behaviors with no internal or external barriers that could restrain behavior after intention (Barber et al., 2014).

3.4. Culture and its dimensions. The role of collectivism

Whenever consumer behavior is studied within a society, certain aspects are expected to be repeated if they apply to most individuals. However, if we extend the study population to other cultures, this may not be the case (Rivera et al., 2000).

Quintanilla (2002) defines culture as: "A set of values, ideas, beliefs, behaviors, norms and symbols created by a society characterized by these, which are conveyed from one generation to another and regulate human behavior. This transfer process is called socialization and it entails a progressive and continuous assimilation by individuals of the elements that integrate the cultural system".

Culture, according to Hofstede (1980):

- Is a collective phenomenon shared by individuals who live or have lived within the same social environment distinguishing the members of one group from others.
- It is learnt, not inherited. It is not intrinsic to human nature or common to all human beings since it is not inherited in the genes. It is not related to one's personality either, which is rather an exclusive set of mind programs that a person does not share with anyone else.

Hofstede believes that culture is a programming of the mind: "Each person has their own models of thought, feelings and potential behaviors learnt throughout their life" (Hofstede, 1999). The origin of these models lies in the social environments in which every individual develops and stores their lived experiences: family, school, work, community, neighborhood, youth groups, etc. This programming of the mind is what Hofstede calls culture.

In this sense, Hofstede (1980) claims that the formation of groups of similar individuals will differ from others in the values preferred by each of them; therefore, cultures can be compared through the approval of value models to a greater or lesser extent. Values interfere in the response to stimuli. Therefore, consumers will feel the drive for adopting behaviors that will help them achieve certain values and avoiding those that hinder their achievements (Loudon and Della Bitta, 1995).

This author established the so-called "Model of Cultural Dimensions" (Hofstede, 1980), distinguishing between four initial dimensions: power distance, individualism vs. collectivism, masculinity vs. femininity, and uncertainty avoidance or risk aversion. Subsequent research conducted by Hofstede and Bond (1988) and Hofstede (1991) added a fifth dimension called "long-term orientation vs. short-term orientation", also known as Confucian Dynamism.

In particular, the dimension individualism-collectivism describes the relationship between the group and the individual (Hofstede and Hofstede, 2001). Individualism is the degree of interdependence a society maintains among its members. Individualism is characteristic of societies where links between people are lax: everyone should take care of themselves and their closest family. Collectivism, on the contrary, is characteristic of societies where people are integrated, since they are born, into strong and cohesive groups that will protect them throughout their lives in exchange for unshakable loyalty (Hofstede, 1999). People having individualistic values tend to be concerned with self-fulfillment and their own career development within an organization or society, while the more collectivist individuals tend to put the benefits of society organization and well-being above their own interests.

This dimension suggests people relate differently in terms of the level of engagement in pro-environmental behaviors (Leung and Bond, 1984; Sinha and Verma, 1987).

Since the adoption of a heating system based on biomass and/or solar power is not an innovation anymore, it is more likely that the adoption of such systems will be higher in the more collectivist countries, characterized by joint decisions and loyalty. Likewise, some previous studies (e.g. Triandis, 1994; Yamaguchi et al., 1995) claim that these cultural dimensions can be approached from an individual level.

Chang et al. (2016) reported that farmers' awareness of the beneficial consequences of restricting household agricultural water and their perception of policy enforcement had significant relationships with their attitudes toward water-saving policies, whereas the effects of the New Ecological Paradigm and collectivism on farmers' attitudes were mediated through their awareness of beneficial consequences and their perception of policy enforcement.

On the other hand, Wu (2006) proved several decades later that cultural values can change over time, since the scores for most dimensions were different from those in Hofstede's study (1980). That is to say, when political, social and economic contexts

change, people's cultural values also change. Therefore, cultural theories must be updated and reassessed periodically.

3.5. Justification for a Cross-cultural research

There are two key debates in cross-cultural research. The first debate refers to the cultural changes driven by the globalization process and to whether globalization can lead to "cultural homogenization" or "cultural diversity" (Walsham, 2000, 2001). The second debate, assuming that globalization and cultural diversity are two elements in a dual system, questioning how cultural differences should be theorized and how the phenomena related to cultural diversity should be studied.

In recent years, the globalization process and the consolidation of many cultural identities have co-existed. In this sense, two approaches emerged: The understanding that culture should be consolidated and homogenous and, on the other hand, the belief that the different cultural identities will overcome their differences and characteristics in order to merge into a common, universal culture (Castells, 2005).

The main objective of intercultural research is to try to determine similarities and differences between behaviours or concepts with respect to different cultures (García-Maroto and Muñoz-Leiva, 2015).

For this, the key is to have or develop measurement instruments valued and equivalent. Once these two factors are assured, this research assesses whether the differences and similarities are true. In other words, comparing different cultures implies equivalence of data, which in turn includes two concepts: equivalence of construction and equivalence of measurement (Poortinga, 1989). This research has contributed measurement scales providing equivalent data.

4. Research methodology

This section explains the main aspects of the methodology applied in this research with regard to the country selection, data collection and the survey applied to the different populations of potential consumers of renewable energy systems.

4.1. Justification for the country selection

Three different countries were selected for this research: Spain, Germany, and Mexico, thus ensuring representation from two different continents (see table 1 in supplementary materials).

The level of individualism in Spanish culture is not high (51), people tend to belong to some group from birth, but work and private life can be wrong. On the other hand, Germans have a greater tendency to regard individuals as more important than groups (67). Finally, in the Mexican country the level of individualism is low (30), which means that it is a collectivist society where group interests prevail over individual ones.

This study uses individualism/collectivism as a core value and, as explained above, this dimension is associated to the environmental concern. Some studies point out that the more collectivist a culture is, the more environmental concern it develops. According to Hofstede, each culture has different values in this regard. Results revealing that there are behavioral differences partly explained by culture.

Also the development of clean energies and the economic situation in the three countries significantly differ from one another. This was an additional incentive for analyzing the perception of each country toward renewable energies. Besides, Mexico was an attractive option as a country of the American continent.

For all these reasons, the combination of these three countries is very interesting for analyzing the behavior towards renewable energies, as each country has a different economic, political and cultural situation and hence consumers have globally different perceptions; as explained previously, renewable energies will have a significant share in the final electrical (and thermal) power consumption at the medium-term.

4.2. Data collection

The data collection method was based on convenience sampling, using online personal surveys, with a structured and pre-coded questionnaire. The participation to the study was voluntary. The target population of the study was composed by people older than 17, living in Spanish, German and Mexican households, potential adopters of renewable energy sources. The goal was to reach 150 subjects per country. By hiring a panel of Internet users with penetration in different countries (Toluna Spain; http://www.toluna.com), we obtained a total of 489 valid questionnaires: 163 Spaniards, 167 Germans and 159 Mexicans (see table 2 in supplementary materials). The field study was conducted from June to October 2015 and full confidentiality as well as privacy were guaranteed regarding survey respondents. Concerning the questionnaire, this research approached a native German translator and a Mexican

native to check for eventual misunderstandings and to adapt the Mexican currency for the collection of income-related data. Since no reliable statistics exist regarding the impact of sample size and composition in the context of this research, the authors considered the total number of households in order to gauge the sampling error for the different groups participating in the study. The sampling error never exceeded 7.5%, a percentage that we consider acceptable for our research and corroborated by the scientific literature.

4.3. Scales used for measuring the study variables and exploratory analyses.

With regard to the measurement scales employed, the study first found a single item for measuring the level of individualism/collectivism of the culture. This item was picked from the scale used in Guzmán's study (2010) for measuring Hofstede's cultural dimensions. The ecological behavior scale (ECE) is based on Karp's (1996) pro-environmental behavior scale. This scale was validated after being modified to integrate up to 44 items, distributed into four factors: city cleaning, water and energy saving, activism and recycling (Pato & Tamayo, 2016). Energy saving and activism were used in a recent study conducted by the University of British Columbia (Senbel et al., 2014). Gatersleben et al., (2002) claim that the studies with a higher number of dimensions may be less useful to find out how to significantly mitigate the environmental impact of household energy consumption. Many studies analyzing the pro-environmental behavior and energy sources only consider activism and energy savings (Olsen, 1981; Gatersleben et al., 2002; Poortinga et al., 2004; Fielding et al., 2008). In this study, the ecological behavior scale was adapted to the energy issue using four items on a Likert scale (where 1 is 'never' and 5 is 'always') referring to two dimensions: activism and energy savings. Both dimensions were corroborated through exploratory factor analysis, which resulted in an explained variance of 78.04%. The reliability analysis based on internal consistency indicators (Cronbach's *alpha* or composite reliability –SCR–) yielded higher values than the reference value (0.6) used in the academic literature (Luque and Ibáñez, 2011). In particular, Cronbach's *alpha* statistic yielded a value of 0.68. The NEP scale employed is integrated by 16 Likert-type items (where 1 is totally disagree and 5 totally agree). It doesn't seem appropriate to use this scale with one single dimension, since two independent subscales can be identified. As in other studies on ideology, social image, or social representation, two opposed cosmovisions seem to persist (San Juan,

1998), which in this particular case result in two ways of relating to nature: anthropocentric and ecocentric. Dimensionality was checked through the exploratory factor analysis, where the two first factors correspond to the two dimensions already mentioned, with an explained variance of 49.13%. The internal consistency of the two scales exceed the limits established by the literature, with values of 0.7 and 0.84 respectively. The scale employed for previous subjective knowledge is a Likert-type scale integrated by 3 items (going from 1 - totally disagree to 5 - totally agree). In these analyses, the one-dimensionality of the scale explains 76.644% of the variance. Internal consistency was demonstrated through the *alpha* value, with an analysis result of 0.83. Van Rijnsoever's and Farla's (2014) scale of renewable energy attributes was adapted to the type of renewable energies used in this study. In particular, it describes aspects that can be encompassed under economic security, costs and sacrifices, and complexity. In this case, this research approached a Likert scale (where 1 is totally disagree and 5 totally agree) with an internal consistency of 0.82, and obtained higher results than the reference value (0.6). Attitude was measured from a classic single-item, 5 point-Likert scale for each energy type (biomass and solar), where 1 is not favorable at all and 5 is very favorable), adapted from Bruner (2009). Intention was measured with a three-item Likert scale (where 1 is totally disagree and 5 totally agree). The first item considers the intention to adopt renewable energy in the future in general and the last two items refer to the intention to adopt of each type of renewable energy considered in the study - biomass and solar panels - in the future. This scale was adapted from Jamieson's scale (1989). The one-dimensionality of intention was proved through a factor analysis whose explained variance was of 73.93%; the internal consistency of the scale analyzed with Cronbach's alpha statistic was of 0.82.

Therefore, all the measurement scales used in the paper are internally consistent, as their Cronbach's *alpha* is above 0.60. This study can therefore report that the scales are generally accepted and have appropriate reliability indicators (Luque, 1997).

Both descriptive and variance analyses (ANOVAs) were applied too, in order to check for differences between countries concerning the several constructs analyzed. Therefore, the data analysis was conducted with SPSS v20 software.

5. Results

5.1. Descriptive analysis and country differences.

It summarizes the analysis on Collectivism, Previous knowledge, Ecological Behavior Scale and Anthropocentrism and Ecocentrism. The level of collectivism in each population is analyzed first through the survey respondents, observing that results match the values provided by Hofstede (1980). Therefore, Mexico (3.83) expressed a greater collectivist behavior, followed by Spain (3.57) and Germany (2.81) on the last position. In the German society, the individualistic behaviors prevail. The applied variance analysis test (ANOVA) confirms the significant differences between countries (F=32.791; g.1. 1=2; d.f. 2=486; p=0.000).

According to previous knowledge, in general, solar power is better known than biomass. Brea and González (1990) stated that consumers use first their own knowledge when making a purchase, since this information processing is easier and more efficient. This means that individuals will have more information on solar energy and will know its attributes better when they need to value the importance of each renewable energy source.

According to the applied ANOVA test, there are no significant differences between countries in terms of knowledge on renewable energies (F=0.48; d.f.1=2; d.f.2=486; p=0.618). In the case of solar energy neither (F=1.32; d.f.1=2; d.f.2=486; p=0.268). However, there are sharp differences regarding biomass (F=6.5; d.f.1=2; d.f.2=486; p=0.020); thus, potential consumers who answered the survey consider biomass is better known in Spain (2.67), followed by Mexico (2.62) and, in the last position, Germany (2.23).

It is worth noting that the respondents claim to know a lot about renewable energies in general, but when they have to answer questions about a particular energy, the level of knowledge decreases in the three regions.

Furthermore, it was confirmed that the cultures with a higher level of collectivism are more concerned about the environment: in Mexico, the average of actions oriented to the care and respect for the environment is 3.64, followed by Spain with 3.36, and lastly, Germany, the most individualistic country in this study, with 3.21, with significant differences (F=11.68; d.f.1=2; d.f.2=486; p=0.000) (see table 3 in supplementary materials).

Regarding anthropocentrism and ecocentrism, we compare their levels in each culture as two dimensions of the NEP scale (see table 1). The first six items explain the anthropocentrism dimension and the rest of them, the ecocentrism. According to

the ANOVA text, there are significant differences in all the cases except items #5 (F=1.43; d.f.1=2; d.f.2=486; p=0.240) and #7 (F=1.77; d.f.1=2; d.f.2=486; p=0.171).

According to this scale and as explained in the literature, anthropocentrism is based on a vision of the world where human beings are users of nature and hence they use it in a licit manner. On the contrary, ecocentrism tends to blame society, governments, and companies, and consider a moral obligation of all actors involved to contribute to the preservation of nature. Therefore, from an ecocentric worldview, there is awareness that human beings are part of nature and their activity must not harm it, but rather act in a way that does not damage the delicate balance of the Earth. On the other hand, anthropocentrism is said to be related to a lower development and a devaluation of the positive effects of pro-environmental behaviors, as well as with the impression that it takes much effort to adopt them. Ecocentrism would be the complete opposite: pro-environmental behaviors are more repeated, the belief in their positive effects is affirmed, and they are not perceived as requiring much effort.

In this analysis, the highest scores for all the countries were obtained for ecocentrism, thus proving that in Spain, Germany, and Mexico this world view prevails over anthropocentrism. Among them, Mexico (4.29) hosts the population displaying the most frequent pro-environmental behaviors, with significant differences (F=9.651; d.f.1=2; d.f.2=486; p=0.000), as already revealed by the EBS. No significant differences were found in the anthropocentric world view (F=0.442; d.f.1=2; d.f.2=486; p=0.643).

Table 1: NEP

		Spain	Germany	Mexico
ANTHROPOCENTR	1. The idea that humanity will face a global ecological crisis has been hugely exaggerated.	2.65	2.29	2.58
	2. The balance of nature is strong enough to cope with the impact of industrialized countries.	2.36	1.95	2.3
	3. Over time, human beings will be able to learn enough about nature's way of working as to be able to control it.	2.8	3.83	2.84
	4. Human ingenuity will make sure we will not make the Earth an uninhabitable place.	2.69	3.07	3.25
	5. Human beings were created to dominate the rest of the nature.	2.25	2.03	2.23
	6. Human beings have the right to change the	2.33	1.77	2.22

I	environment to adapt it to their needs.			
S				
M				
E	7. When human beings interfere with nature,	4.06	3.90	4.1
C	consequences are often catastrophic.			
O	8. Plants and animals have the same right as	4.06	3.95	4.58
C	humans to live.			
E	9. Human beings are seriously abusing the	4	4.2	4.49
N	environment.			
T	10. The balance of nature is very delicate and	3.73	3.97	4.13
R	easily alterable.			
I	11. If things continue in the same way, we will	3.61	3.99	4.14
S	soon experience a big ecological disaster.			
M				

Through the analysis of the two types of energy (biomass and solar) as a whole, the study finds significant differences between countries. In the first place, it is noteworthy that formed opinions in Mexico are stronger and most attributes are more highly valued. Job creation (F=9.41; d.f.1=2; d.f.2=486; p=0.000) is the most valued attribute in Spain (3.36), required investment (F=20.07; d.f.1=2; d.f.2=486; p=0.000) is the most valued in Germany (3.88) and lifespan of the facilities (F=18.78; d.f.1=2; d.f.2=486; p=0.000) is the most valued in Mexico (3.84). In all the cases, household adjustments (F=12.56; d.f.1=2; d.f.2=486; p=0.000) are among the major drawbacks of these clean energies (3.34; 3.8; 3.82; respectively). As proven with the T-test of the related samples, all the previous values show significant differences between regions.

Table 2: Attributes according to countries (means for both energy systems)

	Spain	**Germany**	**Mexico**
I believe constant X* energy supply will be guaranteed in the future.	3.06	3.15	3.63
X creates employment.	3.36	3.56	3.82
The equipment using X has a longer lifespan in the household.	3.34	3.4	3.84
The equipment using X has a short amortization period.	2.79	2.48	3.1
Installing a X system at home requires a major investment.	3.27	3.88	3.82
X energy increases the cost of home maintenance.	2.57	3.25	3.17
For installing X energy, some changes are needed in the house.	3.34	3.79	3.81

The system producing electricity from X energy is very complex.	2.67	3.4	2.97
Once the installation of X energy is completed, it is very hard to use it.	2.49	2.43	3.26

*X=biomass and solar panels

From a global perspective and without making any distinction between the three populations analyzed, the sample had the following particularities (see table 3).

The most highly valued attributes for consumers are the monetary investment in the installation (3.57 for biomass; 3.74 for solar panels), indicating that the investment in solar panels would be higher, with significant differences (T=-4.6; d.f. =488; p=0.000), as well as the required changes in the house (3.69 and 3.61, respectively), this time higher in the case of biomass (T=1.915; d.f. =488; p=0.056). These are therefore the main drawbacks in the purchase decision-making process.

Another highly valued attribute, without significant differences between the two types of energy, is the fact that clean energies create jobs (T=-1.227; d.f. =488; p=0.220). As indicated at the beginning of this paper, it is a fact that these energies have a great potential of creating quality jobs in comparison with fossil fuel energies.

Some remarkable results show that individuals attach more value to the constant energy supply provided by solar power (3.37) than that provided by biomass (3.21), with significant differences (T=-2.813; d.f.=488; p=0.005). Respondents also believe that solar panels will have a larger lifespan (3.67) than biomass (3.38) (T=-5.938; d.f.=488; p=0.000). On the other hand, the cost of home maintenance will be higher for biomass (3.11) than for solar panels (2.89), with significant differences (T=5.302; d.f.=488; p=0.000).

Finally, it is worth noting that scores regarding the perceived level of difficulty for the use of these facilities are not particularly high (2.63 and 2.80, respectively) with significant differences (T=-2.865; d.f.=488; p=0.004), i.e., consumers don't find it difficult to use the equipment under discussion. Respondent didn't find the energy production process difficult either, although scores were slightly higher. Therefore, this would not be a particularly important attribute in the final purchase decision-making.

Table 3: Attributes according to the type of energy

	Biomass	**Solar panels**

I believe constant X* energy supply will be guaranteed in the future.	3.21	3.37
X creates employment.	3.56	3.6
The equipment using X has a longer lifespan in the household.	3.38	3.67
The equipment using X has a short amortization period.	2.9	2.67
Installing a X system at home requires a major investment.	3.58	3.74
X energy involves a high cost of home maintenance.	3.11	2.89
For installing X energy, some changes are needed in the house.	3.69	3.61
The system producing electricity from X energy is very complex.	3.07	2.96
Once the installation of X energy is completed, it is very hard to use it.	2.63	2.80

*X=biomass and solar panels

Hereafter, this study will address the knowledge about the different types of facilities (biomass and solar power) based on their attributes. The dimensions considered in this study: economic security, costs and sacrifice, and complexity will also be assessed.

The following table shows the economic security dimension (table 4). For the first item, results show that Germans consider biomass (3.26) to be more constant than solar energy (3.04) with significant differences (T=-2,028; d.f.=166; p=0,044), while in Spain, without significant differences (T=-1.000; g. l.=162; p=0.319), and in Mexico, with significant differences (T=-7.366; d.f.=158; p=0.000), consumers believe that solar energy brings more security.

With regard to job creation, there are no significant differences between the two types of energy (Spain: T=0.446; d.f.=162; p=0.656, Germany: T=-0.843; d.f.=166; p=0.401 and Mexico: T=-1.275; d.f.=158; p=0.204); it is, however, a quite important characteristic for all consumers.

Table 4: Economic security

	Spain		**Germany**		**Mexico**	
	B*	S**	B*	S**	B*	S**
I believe constant X* energy supply will be guaranteed in the future.	3.05	3.41	3.26	3.04	3.31	3.95
X energy creates employment.	3.37	3.35	3.54	3.59	3.77	3.87

*B: Biomass, **S: Solar panels

Regarding the focus on the costs and sacrifices (table 5) involved in the purchase and use of these equipment as perceived by the respondents, this study found that, in the first place, concerning lifespan, Germans (T=-4.570, d.f.=166, p=0.000) and Mexicans (T=-5.88, d.f.=158, p=0.000), with significant differences between both energy sources, believe the lifespan of solar panels is longer than that of biomass.

In the second place, all the populations believe that investment in biomass is paid off earlier than in solar panels, mainly Mexicans and Germans (Spain: T=1.736; d.f.=162; p=0.084; Germany: T=4.200; d.f.=166; p=0.000; Mexico: T=3.092; d.f.=158; p=0.002), although Mexicans don't consider it to be a long process, but rather an early payoff.

Potential users also agree with the statement that investment is higher in solar panels than in biomass (Spain: T=-2.926; d.f.=162; p=0.004; Germany: T=-3.023; d.f.=166; p=0.003; Mexico: T=-1.979; d.f.=158; p=0.050).

With regard to the maintenance cost of both installations, results show that the Spanish population does not consider it a big inconvenient, as it was low scored as compared to Germany and Mexico. The three cultures value biomass as the most expensive energy source in comparison with solar panels, with significant differences (Spain: T=3.191; d.f.=162; p=0.002; Germany: T=3.145; d.f.=166; p=0.02; Mexico: T=2.919; d.f.=158; p=0.004).

Lastly, concerning the required changes in the house for installing these technologies, there are no significant differences in Spain (T=0.464, d.f.=162, p=0.643) or Mexico (T=0.406, d.f.=158, p=0.685) between both energy sources. Germans (T=2.244, d.f.=166, p=0.026) believe that biomass systems require more changes in the house.

Table 5: Costs and sacrifices

	Spain		**Germany**		**Mexico**	
	B*	S**	B*	S**	B*	S**
The equipment using X energy has a longer lifespan in the house.	3.31	3.14	3.22	3.59	3.63	4.06
The equipment using X has a short amortization period.	2.83	2.74	2.65	2.3	3.21	2.99
Installing a X system at home requires a major investment.	3.18	3.36	3.78	3.98	3.76	3.89
X energy involves a high cost of home maintenance.	2.67	2.47	3.35	3.14	3.3	3.05

For installing X energy, some changes are needed in the house.	3.35	3.33	3.88	3.71	3.83	3.8

*B: Biomass **S: Solar panels

Concerning the attributes referred to complexity in general (table 6), Spain is the population that attached less importance to it, as compared to Germany and Mexico. With significant differences for the first item, Spain (T=1.994; d.f.=162; p=0.048) and Mexico (T=4.419; d.f.=158; p=0.000) consider that the electricity production process is more complex with biomass. Opposed to the Germans' opinion (T=-2.796; d.f.=166; p=0.006) that the process would be more complex with solar panels.

However, no significant differences were identified between countries in the case of biomass concerning the difficulty of use (F=1.008; d.f.1=2; d.f.2=486; p=0.366). As a general information, the use of biomass boilers is perceived to be more complex for households than solar panels, with significant differences in Spain (T=2.426; d.f.=162; p=0.016) and Germany (T= 5.269; d.f.=166; p=0.000). On the contrary, Mexican respondents perceive the use of solar panels to be more complex (T= 3.569; d.f.=158; p=0.000).

Table 6: Complexity

	Spain		**Germany**		**Mexico**	
	B*	S**	B*	S**	B*	S**
The system producing electricity from X energy is very complex.	2.74	2.6	3.32	3.48	3.15	2.78
Once the installation of X energy is completed, it is very easy to use it.	2.55	2.43	2.63	2.22	2.72	3.81

*B: Biomass, **S: Solar panels

It was observed that there is a higher intention to adopt renewable energies in general (F=35.536; d.f.1=2; d.f.2=486; p=0.000) and solar panels (F=54.127; d.f.1=2; d.f.2=486; p=0.000) in Mexico than in the other two countries, which obtained an average of 4.55 and 4.41 respectively. Climate in Mexico may explain the lack of differences in the second variable of intention (F=0.991; d.f.1=2; d.f.2=486; p=0.372)

6. Conclusions, limitations and avenues for future research.

6.1. Conclusions.

From the available scientific and informative literature, different development contexts for renewable energies can be seen on each country's market. In Germany, sector is continuously growing and the country is a leader in clean energies, beating records in the past year. The development of renewable energies in Spain is at a standstill due to the Royal Decrees approved for investment and their share of the GDP over the past years. The situation is different in Mexico, where the sector is just waking up in recent years due to its high external dependence, meaning that the main investments come from other countries.

The focus of this research was to analyze the consumer's perception of solar and biomass energy, including the determinant role of culture. This study found that more collectivist cultures show a greater concern about the environment and their behaviors are more focused on the respect for nature, as they believe in its positive effects and hence are more willing to use renewable energies.

Among the findings of this research, the previous idea is reinforced, since Mexico is the most collectivist culture, followed by Spain, while Germany holds the last position. Likewise, ecological behaviors such as avoiding energy waste or engaging in environmental conservation activities are more common in Mexico, followed by Spain and, lastly, by Germany. This approach is related to some extent to previous acceptance.

The NEP scale also shows that the predominant view in the three cultures is ecocentrism. Besides, by analyzing every case, the study revealed once again that the more environmentally friendly behaviors are developed in Mexico.

The study has also allowed us to discover some aspects about the two renewable energy sources - biomass and solar - consumed at the household level, distinguishing between nationalities.

In the first place, previous knowledge about biomass is greater in Spain, followed by Mexico and Germany.

When the two are discussed together, research shows that the most important factor for the Spanish population is job creation, while the biggest concern in Germany is the investment involved in the use of these energy sources. On the other hand, the most highly valued advantage in Mexico is the lifespan of the installations. Likewise, the changes required in the house for installing renewable energies is an extremely important aspect for all.

Therefore, considering the sample as a whole, we can conclude that the monetary investment and the changes in the house required by these installations are the main drawbacks in the decision-making process about the adoption of solar panels or biomass as a source of electricity. On the other hand, job creation is a highly-valued attribute by the three populations. Besides, consumers do not find great difficulties in terms of perceived complexity in the use of these installations at home.

The analyses conducted in order to establish the differences between the three countries and the two types of energy concerned are referred below. With regard to the continuity of energy supply, Mexico attaches more value to solar energy as a constant than to biomass, while the opposite occurs in Germany, probably because there are less sunlight hours in Germany. However, both countries value positively the lifespan of solar panels as compared to biomass technology.

Concerning the amortization of the installations, all study respondents agree with the fact that it takes longer to recover investment in solar panels than in biomass technology. However, this process is not perceived as a long one in Mexico, so for Mexicans this is not an inconvenient.

Considering the monetary investment involved, the three populations believe that solar energy brings a higher benefit than biomass. Nonetheless, once the investment is made, consumers perceive the cost of maintenance as higher for biomass than for solar power. For Spaniards, however, this would not be a major inconvenient in their purchase decision-making. Likewise, the changes required in the house for installing the necessary equipment and machinery are more highly valued for biomass by Germans, without significant differences among the others.

Finally, it is worth noting that Mexico is the country where the population is most likely to adopt renewable energy systems, especially regarding solar panels, followed by Spain and, lastly, Germany. Results obtained by this study show that the country which ranked the first in collectivism is actually the one with the highest intention to purchase eco-friendly products (see table 4 in supplementary materials).

6.2. Managerial implications

These findings also have practical implications for marketing, mainly related to segmentation and effort focusing. In terms of segmentation, the results of this study suggest that the target segments for environment-friendly products like renewable energies may be the ones with more collectivist values. In the same way, advertising

and communication efforts may allocate resources to clean energies as a way of contributing to sustainable development.

This study has revealed the main drivers and barriers to adopt renewable energy systems at the household level for the populations of the three countries analyzed. Both private companies and public institutions will benefit from the new knowledge when developing their marketing strategies.

First, considering that the monetary investment and the changes needed in the house are the main barriers to the adoption of clean energies, it is central to contribute to the development of this type of energies through government incentives, state subsidies, and economic policies aimed at reducing the cost for the final user. In addition, it is necessary to increase the awareness of consumers regarding the benefits obtained through the use of renewable energy systems. From an environmental perspective, individuals from the countries with higher values related to collectivism are the most aware with regard to pollution problems and natural resources. Therefore, an effective marketing strategy should involve emotional values related to pro-social behavior, including future generations. On the other hand, in order to foster sales of clean energy systems, marketing campaigns should illustrate the fact that consumers do not regard their installation as especially complex. In order to achieve this goal, a highly trained salesforce with reliable and relevant knowledge would be a requisite. These practices provide significant value to customers and companies.

Finally, this study found that Mexicans are more likely to adopt solar energy compared to Germans since Mexico has more sunlight hours and solar panels are more valued in Mexico compared to biomass boilers. Thus, it would make sense for solar power companies to focus on Mexico. Besides, companies should find out the reasons why the perceived monetary investment required for solar panels is higher than that of biomass boilers. In this case, a proper aid policy should mitigate the differences in the intention to adopt of these clean energy systems.

6.3. Limitations and avenues for future research

This study has several limitations. One of the main research limitations was the sample size, as a bigger sample than the one used is every country was not available. Therefore, caution is recommended before extrapolating the results to the total population of the three target countries.

On the other hand, this study analyzes renewable energies, revealing that the values related to collectivism in each culture influence the pro-environmental behaviors of these societies, and hence, attitude and intention towards clean energies. The pro-environmental behavior is based on concepts such as energy saving, which is why caution is recommended before extrapolating these results to other fields related to respect and care for the environment, such as reducing the use of plastic bags, recycling, etc.

Finally, we propose different lines of research for future studies, such as: a) expanding the study in order to assess other populations, countries and/or continents, with the aim of completing this analysis from a cross-cultural approach; b) including other cognitive and sociodemographic variables (such as the level of studies) as determinants of the adoption of renewable energies; c) delving into the analysis of the characteristics of the sample by incorporating other significant variables such as gender, age, and income level.

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SUPPLEMENTARY MATERIALS

Table 1: Hofstede's cultural dimensions

	Spain	Germany	Mexico
Power distance	57	35	81
Uncertainty avoidance	86	65	82
Individualism	51	67	30
Masculinity	42	66	69
Long-term orientation	48	83	24

Source: Hofstede (2017).

Table 2: Sample characteristics

			SPAIN	GERMANY	MEXICO
Gender	Male		41.2 %	60.9 %	55.3 %
	Female		58.8 %	39.1 %	44.7%
Age	17 - 24		14.8 %	27.2 %	36.3 %
	25 - 44		40.1 %	43.8 %	34.8 %
	45 - 64		42.9 %	29 %	28.6 %
	Over 65		2.2 %	-	-
Civil status	Single		37.4 %	40.2 %	38.5 %
	Couple without children		16.5 %	29.6 %	5.6 %
	Couple with children		32.4 %	21.3 %	50.9 %
	Divorce without children		4.4 %	3 %	0.6 %
	Divorce with children		4.4 %	5.9 %	2.5 %
	Widower without children		1.6 %	-	-
	Widower with children		1.1 %	-	1.2 %
	Other		2.2 %	-	0.6 %
Household size	1 member		15.4 %	17.8 %	4.3 %
	2 members		18.1 %	36.1 %	8.7 %
	3 members		21.4 %	18.9 %	20.5 %
	4 members		35.7 %	18.9 %	31.7 %
	5 members		7.1 %	4.7 %	21.1 %
	6 members o more		2.2 %	3.6 %	13.7 %
Income level	Less than 1,200 €	Less than $ 3,420	12.1 %	16.6 %	7.5 %
	1,200 - 1,800 €	$ 3,420-8,610	28.6 %	14.2 %	9.3 %
	1,800 – 3,000 €	$ 8,610-11,700	25.3 %	30.2 %	12.4 %
	3,000 – 5,000 €	$ 11,700-14,700	21.4 %	26.6 %	12.4 %
	More than 5,000 €	$ 14,700-44,200	2.7 %	3.6 %	26.7 %
		$ 44,200-107,000	9.9 %	8.9 %	9.9 %
		More than $			8.7 %
					13 %

DN/NR	107,000	
	DN/NR	

Table 3: Collectivism, Previous knowledge, Ecological Behavior Scale and Anthropocentrism and Ecocentrism (average)

Variable	Spain	Germany	Mexico
Collectivism	3.57	2.81	3.83
Previous knowledge Renewable Energies	3.31	3.23	3.33
Previous knowledge Biomass	2.67	2.23	2.62
Previous knowledge Solar	2.76	2.78	2.96
Ecological Behavior Scale (EBS)	3.36	3.21	3.64
Anthropocentrism	2.51	2.49	2.57
Ecocentrism	3.89	4	4.29

Table 4: Intention to adopt (average)

	Spain	Germany	Mexico
Renewable energies intention	4.1	3.6	4.55
Biomass intention	3.56	3.52	3.69
Solar panel intention	3.92	3.15	4.41