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WILLINGNESS TO PAY FOR RENEWABLE ENERGY BY THE RESIDENTIAL SECTOR IN AGUASCALIENTES

TESINA

QUE PARA OBTENER EL GRADO DE

MAESTRO EN ECONOMÍA AMBIENTAL

PRESENTA

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Abstract

Using the discrete choice experiment method for economic valuation, this thesis explores the preferences and willingness to pay (WTP) that households from the city of Aguascalientes have towards distinct economic and environmental attributes that a supply of residential renewable energy may entitle. The results show that there is a positive WTP for renewable residential energy. Further, households have a preference for solar energy over biomass or a mix of both. The results also show that households assign more value to the creation of new jobs than to any other environmental attribute. Finally, with the means of a split sample and the making of a treatment in the study, it is found that respondents show distinct valuation if more information is given to them.

Keywords: Choice Experiment; Renewable Energy; Energy Transition Law; Solar; Biomass; Willingness to Pay; Electricity

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Chapter 1

Introduction

In December 2015, the Mexican congress passed a national law called "Energy Transition Law" (ETL), with the objectives of "[...]regulate the sustainable use of energy and set the goals regarding clean energies [1] and reduction of pollutant emissions from the electric industry, keeping the competitiveness of productive sectors[...]" , this law provides a framework for the reduction of greenhouse gases (GHG) emissions, promotes energy efficiency and clean energies.

The ETL establishes a national strategy which sets clean energy and energy efficiency goals. Among these goals, the law states a minimum participation of clean energies in the total energy generation of 25% by the year 2018, 30% by 2021 and 35% by 2024. With an electric sector responsible of a quarter of total GHG national emissions (INEEC, 2018), this law aims to meet the commitments of the Paris Climate Change Agreement, where Mexico compromised to reduce 22% of total GHG emissions in the year 2030 and 51% of black carbon emissions with respect to the line base or the trend growth of the goods, services and productive activities which generate them.

As a tool to achieve these goals, the law introduces the Clean Energy Certificates (CELs).

[1] The Mexican law considers clean energies those produced by renewable, nuclear and other not conventional technologies such as efficient cogeneration

The regulatory energy comission in Mexico (CRE by its Spanish acronym) is responsible to grant a CEL for each MW/h of electricity produced by a generator using clean energy technologies. Mexican industries and energy suppliers are committed to consume a fixed percentage of all their electric needs from clean energy sources. The requirements for 2018 were 5%, and 5.8% by 2019. This percentage increases every year, in 2020 the requirement will be 7.4% ,10.9% in 2021 and 13.9% in 2022.

With the implementation of these laws and instruments, the participation of clean energies in the total energy generation increased almost 21.71% in the 2017-2018 period ("SENER, 2018"). Within these energies, non conventional renewable sources achieved a major growth: solar energy and energy from biomass grew 257% and 145% respectively for the same period. With these numbers, by November 2018 the total energy generation by clean energies reached 24.12% of the total, less than one percentage point to reach the goal of 25% established in the ETL.

Under the light of these figures, it can be said that the energy policy was able to fulfill the commitments established in the ETL. However, in December 2018 a new administration took over. The new government has made decisions in the opposite direction of the ETL goals promoting the development of fossil energy sources such as: the construction of a new refinery, the commitment to acquire thousands of tones of carbon for the production of electricity, and suspended electric auctions. The reasons behind this change of policy haven't been publicly clarified, but the word "energy security" is a phrase that is repeated constantly in the official discourses. Thus, concerns regarding the availability and accessibility of energy, as well as the Mexican energy sovereignty, may be some of the motives that trigger this change in energy policy.

The conflict that arises while balancing the goals established in the ETL and satisfying the energy needs of a developing country, brings us to reflect about the necessity of analyzing the energy policy from a global point of view. Indeed: an energy policy may entail not only environmental and welfare economic conflicts, but social conflicts as well (Silva Ontiveros, Munro, and Melo Zurita, 2018). In order to minimize these conflicts, authors Sovacool and Dworkin (2014) propose to incorporate the Information Principle in designing and implementing energy policy. This Information Principle states that "[...]people should have access to high quality information about energy and the environment, as well as fair, transparent and accountable forms of energy decision making[]" (Sovacool and Dworkin, 2014).

Taking the Information Principle as harmonizing thrust an energy policy which pursues the promotion of clean energies means not only to provide information to consumers about the cost and benefits of these energies, but it also means to know the valuation that consumers hold to these energies. Taking into account the public valuation in the implementation of energy policy might be the key to its successful achievement.

This research proposes a first approach to the valuation of renewable energies by the residential sector in the city of Aguascalientes, Mexico. It is expected that households valuate positively the increase of renewables in their total residential energy mix. Additionally, it is expected to find that, when the consumer is provided with more information about the advantages of renewable energies, his valuation towards these technologies should increases. Finally, it is tested whether consumers respond differently when confronted with a decision making situation knowing the real price of their electric bill versus a situation when the consumer just recalls his electric bill.

The specific research questions that this thesis aims to explore are:

1. Does a willingness to pay for renewable residential energy exist in Aguascalientes?

2. Does the consumer has distinct valuation towards distinct types of renewable energy?

3. What aspects of a renewable energy investment does the public valuate more?

4. Does the consumer show distinct valuation if he has more information about renewables?

5. Is there any difference between the valuation of a consumer who just recalls its electric bill versus a consumer who knows its real bill?

Overall, the research questions seeks to explore valuation towards a good that does not have a market yet. Thus, the research demands the use of economic valuation. The first research questions aim to identify the valuation towards distinct characteristics that a particular supply of renewable energy by the residential sector scheme mat entitle. In this sense, using the discrete choice experiment for economic valuation (CE) as empirical approach will be useful. The reason of this relies on the overall objective of a CE, which is the estimation of economic values for characteristics of an environmental good that is subject of analysis (Patricia A., Boyle, and Brown, 2003). Under this framework, it is possible to isolate the valuation towards distinct types of renewable energy, as well as the distinct aspects of a renewable energy investment. Thus, the CE method is the most appropriate for use in this context. To attend research questions four and five, the implementation of treatment and control groups, as well as a split sample is carried out. Details are described in the empirical strategy chapter.

The rest of the thesis is structured as follows: chapter two contains a literature review of studies that use the CE method to explore the valuation of consumers valuation towards residential renewable energy. Chapter three introduces the methodology used and chapter four explains the empirical strategy to follow. Chapter 5 describes the data and finally, chapter six and seven presents the results and conclusions of this research.

Chapter 2

Literature Review

Studies that explore preferences towards residential renewable energy are relatively recent. The very first study found was made by Farhar (1996). This study aims to estimate a national willingness to pay (WTP) for a higher share of renewable energy in the electricity mix in the U.S. The results show that approximately 40% to 70% of the users are willing to pay a premium for an increase in the share of renewables in their residential consume.

Since 2006, the literature that analyses public preferences towards renewable energy sources has been on the rise (Sundt and Rehdanz, 2015). Meta-analisis studies of this subject (Sundt and Rehdanz, 2015; Ma *et.al.* 2015) identify that most of the studies use the Contingent Valuation method (CV), but the Choice Experiment method (CE) presents a rising tendency. These findings are consistent with the fact that the CE method has grown rapidly since mid-nineties, being at the present the most used method within the class of discrete choice experiment (Patricia A., Boyle, and Brown, 2003).

This section will focus on studies that employ the CE method to analyze public preferences because it is the method that this research implements. The literature review is categorized by the particular objectives of the studies and the attributes used. Tables 2.1 and 2.2 summarizes the studies reviewed by this categorization.

Table 2.1: Studies Reviewed by Attributes and Objectives

Objectives of the study	**Authors and year**	**Environmental Attributes**	**Welfare Attributes**
Analyse preferences for a mix of distinct energies	Murakami, et al. 2015	2: CO_2 emissions and portfolios of distinct energy sources	1: Electric bill
Analyse preferences for a mix of distinct energies	Cicia, et al. 2012	1: Type of energy	1: Electric bill
Analyse preferences for a mix of distinct energies	Koisenus 2013	2: CO_2 reductions, impact on local biodiversity	2: Electric bill and jobs
Analyse preferences for a mix of distinct energies	Borchers, et al. 2007	4: Type of energy and percentage participation in the total energy mix	2: Electric bill
Analyse preferences for a mix of distinct energies	Gracia, et al. 2011	4: Type of energy and percentage participation in the total energy mix	2: Electric bill and origin of the energy
Analyse preferences for a mix of distinct energies	Vecchiato, et al. 2015	3: Type of energy, size and distance of the power plant from the respondent's living area	2: Electric bill and origin of the energy
Analyse preferences for a mix of distinct energies	Yoo, et al. 2014	4: One for every type of energy	2: Electric bill and jobs

Source: Own elaboration

All of the studies reviewed are made for developed countries, with most of the studies carried out for members of the EU (Longo, Markandya, and Petrucci, 2008; Alberini *et.al.* 2018; Kosenius and Ollikainen, 2013; Vecchiato and Tempesta, 2015; Gracia, Barreiro-Hurlé, and Pérez y Pérez, 2012; Bergmann, Hanley, and Wright, 2006; Soliño *et.al.* 2012; Cicia *et.al.* 2012). The reason of this relies on the fact the EU established mandatory targets for an overall 20% share of renewable energy source of all energy consumption by 2020[1].

The literature reviewed differs in what kind of public preferences associated with renewable

[1]The mandatory shares differ by country, e.g., for Denmark is 30% and Spain 20%

Table 2.2: Studies Reviewed by Attributes and Objectives (continued)

Objectives of the study	**Authors and year**	**Environmental Attributes**	**Welfare Attributes**
Analyse preferences for an energy policy that promotes renewables	Kim, et al. 2018	1: Share of energy sources	5: Number of blackouts, duration of blackouts, social contribution, smart meter and electric bill
Analyse preferences for an energy policy that promotes renewables	Alberini, et al. 2018	1: CO_2 reductions	3: Goal of the policy, policy mechanism, cost of the policy per household
Analyse preferences for an energy policy that promotes renewables	Longo, et al. 2015	2: CO_2 reductions	3: Size of electric blackouts, jobs and electric bill
Analyse preferences for an energy policy that promotes renewables	Bergmann, et al. 2006	3: Impacts on landscape, impacts on wildlife and impacts on pollution	2: Electric bill and jobs
Analyse preferences for one kind of renewable energie	Susaeta, et al. 2011	2: CO_2 reductions forest habitat improvement	1: Electric bill
Analyse preferences for one kind of renewable energie	Solin, et al. 2012	3: GHG reductions, pressure on non renewable resources, and reductions in risk of forest fires	1: Electric bill and jobs

Source: Own elaboration

energies are trying to explore: analyse preferences for one kind of renewable energy (Susaeta *et.al.* 2011; Soliño *et.al.* 2012), analyse preferences for a mix of distinct energies (Murakami *et.al.* 2015; Cicia *et.al.* 2012; Kosenius and Ollikainen, 2013; Borchers, Duke, and Parsons, 2007; Gracia, Barreiro-Hurlé, and Pérez y Pérez, 2012; Vecchiato and Tempesta, 2015; Yoo and Ready, 2014), and analyse preferences for an energy policy that promotes renewables (Alberini *et.al.* 2018; Longo, Markandya, and Petrucci, 2008; Bergmann, Hanley, and Wright, 2006; Kim, Park, and Lee, 2018). With respect to the similarities observed in these studies, all of them incorporate as welfare attribute the amount of electric bill, although in different metrics. For example, in the studies of Gracia, Barreiro-Hurlé, and Pérez y Pérez (2012) and Susaeta *et.al.* (2011), the welfare attribute is an increase for each Kw/h consumed. Murakami *et.al.* (2015)

use the average amount of electric bill in the region of study to include absolute fixed amounts of monthly electric bill in the alternatives. Others also use fixed amount increases, but in different time frames: Lancaster (1966) uses quarterly amounts, while Kosenius and Ollikainen (2013), Soliño *et.al.* (2012), and Bergmann, Hanley, and Wright (2006) use yearly fixed amounts. The most used time frame for fixed estra-payment is matched with the time frame of the electric bill, which could be monthly or bimonthly. This is the case for Kim, Park, and Lee (2018), Cicia *et.al.* (2012), Borchers, Duke, and Parsons (2007), Yoo and Ready (2014), Soliño *et.al.* (2012), and Vecchiato and Tempesta (2015). Finally, Alberini *et.al.* (2018) use four levels of fixed amounts of annual increases in the electric bill in a 10 year time horizon.

Also, a high proportion of them include the welfare attribute of jobs or a proxy of it, such as region of origin of the energy (Gracia, Barreiro-Hurlé, and Pérez y Pérez, 2012; Vecchiato and Tempesta, 2015). Since prices and jobs are impacted by the promotion of renewables and are the most common attributes associated with welfare, the inclusion of these makes sense if a researcher is trying to explore valuation towards renewable energy. Regarding the environmental attributes, one that appears in many studies is reductions of GHG (Murakami *et.al.* 2015; Kosenius and Ollikainen, 2013; Alberini *et.al.* 2018; Longo, Markandya, and Petrucci, 2008; Susaeta *et.al.* 2011) due to it is the main environmental attractive of renewable energies.

Regarding the similarities by objective of study, the literature that analyzes preferences over one specific source of renewable energy includes one environmental attribute which is related to the source of energy evaluated; e.g.,Soliño *et.al.* (2012), include an attribute called reductions in risk on forest fires. This is because the energy valuated is forest biomass and the promotion of this source decreases the risk of forest fires. This kind of attributes wouldn't make sense in other scenario.

With respect to the studies that analyse preferences for an energy policy that promotes renewables, it is found that they include very specific attributes no seen in other studies; e.g., Alberini *et.al.* (2018),uses attributes such as “goal of the policy” and “mechanism of the policy” not seen in any other study. This is because the focus is put on the valuation of the renewable policy and its implementation. The same circumstance happens with the study of Kim, Park, and Lee (2018), which includes attributes such as “installation of a smart meter”.

Finally, considering the studies that analyze preferences over distinct energies, almost all of them incorporate as environmental attribute the energy sources to valuate. (Murakami *et.al.* 2015; Cicia *et.al.* 2012; Borchers, Duke, and Parsons, 2007; Gracia, Barreiro-Hurlé, and Pérez y Pérez, 2012; Vecchiato and Tempesta, 2015; Yoo and Ready, 2014).In these, the levels are the distinct source of energy. Many of them incorporate as well the participation of the referred source of energy in the total energy supply mix (Borchers, Duke, and Parsons, 2007; Gracia, Barreiro-Hurlé, and Pérez y Pérez, 2012; Murakami *et.al.* 2015).

Almost all of the studies found that consumers valuate positively increase in the share of renewables in the energy supply mix. Only the study of Gracia, Barreiro-Hurlé, and Pérez y Pérez (2012) finds that the valuation is only positive when it is solar energy. Also, the studies that evaluate preferences over distinct renewable energies find distinct valuation towards these distinct sources. It is interesting to notice that, when the studies incorporate the valuation toward solar energy compared with other renewable sources, this specific source is the one preferred one (Borchers, Duke, and Parsons, 2007; Vecchiato and Tempesta, 2015; Gracia, Barreiro-Hurlé, and Pérez y Pérez, 2012; Yoo and Ready, 2014; Cicia *et.al.* 2012). Also, when comparing the preferences towards nuclear energy, the studies find that this particular source is negatively valued (Cicia *et.al.* 2012; Murakami *et.al.* 2015).

In a large majority of these studies, their results show the existence of heterogeneous preferences towards the valuation of renewable energies (Gracia, Barreiro-Hurlé, and Pérez y Pérez, 2012; Kim, Park, and Lee, 2018; Cicia *et.al.* 2012; Yoo and Ready, 2014; Alberini *et.al.* 2018; Susaeta *et.al.* 2011; Kosenius and Ollikainen, 2013; Bergmann, Hanley, and Wright, 2006). The results in these studies suggest that heterogeneous preferences are driven by socioeconomical individual characteristics such as income, age, education and environmental attitudes.

As stated before, this literature review reveals that all of the studies that use the CE method to asses public preferences towards renewable energy are made for developing countries. Also, the review reveals that in most studies the welfare attribute of amount of electric bill is far from being individual by every decision maker. The only cases where this attribute is individual are when the welfare attribute is an increase for each Kw/h consumed. But since this means that every decision maker would have to remember the amount of Kw/h that his household consumes and then immediately do the calculation of how much this increase would reflect in the total electric bill, it is expected that the decision maker chooses thinking in an amount that does not reflect the reality of the alternative. This is a constant flaw in the literature because the CE method requires real life scenarios in the distinct alternatives and clearly, non-individual scenarios are far from being real.

This research is, to the best of my knowledge, the very first to incorporate individual price scenarios amounts in the method design while assessing public preferences for renewables using the CE method. Details of how this is done is included in the methodology chapter of this thesis. Another contribution of this research is that this study is the first that analyses these preferences for a developing countries using the CE method.

Chapter 3

Methodology

The CE method is based on primary data collected by direct survey to people. Typical surveys of the CE method present hypothetical but realistic market scenarios to the respondent. The characteristics of such scenarios are well described and defined in the survey. Distinct scenarios (alternatives) differentiated by a set of characteristics (attributes) are presented to the respondent. A set consisting of distinct scenarios is called a choice set. In choosing the preferred alternative, respondents are asked to behave like in a real market scenario. Thus, the importance of realistic and compressible scenarios to the respondent is a fundamental requisite for a successful CE.

In practice, the attributes of the evaluated good may be qualitative or quantitative. Once attributes and levels have been determined, the researcher decides the number of alternatives to present in each choice set and the number of choice sets in the survey. These numbers depend on the complexity of the analysis and may be derived from focus group, pilot test and expert advise (Patricia A., Boyle, and Brown, 2003). Alternatives must provide enough variation over the attribute levels to allow the researcher to identify preference parameters associated with the attributes .

Theoretical foundations of the CE method are Lancaster's theory of value and the random utility theory. Lancaster (1966) asserted that the utility that an individual obtains from consuming one good comes from the characteristics of that good, rather than the consumption of the good itself. The total utility from a good is then determined by the sum of the utility of its characteristics.

Random utility theory is developed under an assumption of utility-maximizing behavior by the decision maker. Models that can be derived in this way are called random utility models (RUMs). RUMs are derived as follows. A decision maker, labeled n, faces a choice among J alternatives. The utility that a decision maker obtains from alternative j is $U_{nj}, j = 1, ...J$. This utility is known to the decision maker, but not by the researcher. The researcher observes some attributes of the alternatives faced by the decision maker, labeled $X_{nj} \forall j$, and some attributes of the decision maker, labeled S_n, and can specify a function that relates these observed factors to the utility of the decision maker. Thus, the researcher specifies a function $V_{nj} = V(X_{nj}, S_n) \forall j$. This function is typically called “representative utility". Because there are aspects of the utility that the researcher does not observe, $V_{nj} \neq U_{nj}$. From this, it is clear that $U_{nj} = V_{nj} + \epsilon_{nj}$, where ϵ_{nj} captures the factors that affect utility not included in V_{nj}.

The probability that a decision maker n chooses alternative i is:

$$P_{ni} = Prob(\epsilon_{nj} < \epsilon_{ni} + V_{ni} - V_{nj} \ \ \forall j \neq i) \tag{3.1}$$

Using the density $f(\epsilon_n)$, this cumulative probability can be rewritten as:

$$P_{ni} = \int_{\epsilon} I(\epsilon_{nj} - \epsilon_{ni} < V_{ni} - V_{nj} \ \ \forall j \neq i) f(\epsilon_n) d\epsilon_n \tag{3.2}$$

Logit model is derived by assuming that each ϵ_{nj} is distributed independently, identically extreme value. If the representative utility is specified to be linear in the parameters, the logit probabilities of a decision maker n choosing alternative i is:

$$P_{ni} = \frac{e^{\beta' x_{ni}}}{\sum_j e^{\beta' x_{nj}}} \tag{3.3}$$

Thus, in a sample, the probability of each person choosing the alternative that he was observed actually to choose is:

$$L(\beta) = \prod_{n=1}^{n} \prod_{i} (P_{ni})^{y_{ni}} \tag{3.4}$$

The log-likelihood function is then:

$$LL(\beta) = \sum_{n=1}^{N} \sum_{i} y_{ni}(P_{ni}) \tag{3.5}$$

And the estimator is the value of β that maximizes this function (Train, 2003).

Chapter 4

Empirical Strategy and Survey Design

The first step in making a CE is to decide the attributes and levels to be used. These attributes should be realistic, easy to understand to the respondent, and relevant to the problem under analysis (Patricia A., Boyle, and Brown, 2003). Since a CE is by construction an attribute-driven experimental technique, the determination of the attributes and levels is key to provide validity to our results. Following the previous literature and given the research questions, the set of attributes and levels are displayed in table 4.1.

Table 4.1: Attributes and Levels used

Attributes	**Levels**
Source of energy	Solar, biomass and mix
Energy percentage in the total supply mix	10%, 20% and 30%
New jobs created	100, 1000 and 2000
Percentage increase in the bimontlhy electric bill	5%, 20% and 40%

Source: Own elaboration

The selection of the source of energy attribute is apparent. The decision of assignig those levels is because according to the Renewable Energy Roadmap, made by the International Renewable Energy Agency (IRENA) and the Mexican Energy Ministry (SENER), the state of Aguascalientes has the potential of generating renewable energy from solar photovoltaic (PV) and biomass sources.

The energy percentage in the total mix is an attribute frequently seen in the literature and it is relevant to study since, under the light of the ETL and its goals, the percentages of clean energy in the total energy generation is a written metric for achieving those goals. As stated before, the law stipulates that for the year 2021, 10.9% of residential energy must come from clean energies and the total energy generation from these sources must be at hte level of 30%. In this regard, setting the levels at 10%, 20% and 30% makes sense because this fall in an interval contemplated in the law to happen in the near future. Given this, it will be of great interest to explore the valuation of households towards these goals stipulated in the ETL.

The welfare attributes of price and jobs are persistently present in the great majority of studies and this research will not be the exception. To set the levels of jobs, it was found that, on average, one Gigawatt (GW) of solar PV power creates 8,250 new jobs while one GW of biomass power creates 31,000 new jobs (IRENA, 2015). At first, it was thought to set the number of new jobs according to its source so as reflect these differences in potential jobs. However, it was decided to apply the same levels to all different sources with the purpose of isolating the preferences for the job attribute. The levels used for the price attribute do not differ from average values found in the literature and were approved by experts advice.

Once the attributes and levels have been decided, the next step is to create the choice sets according to an "orthogonal coding". Hensher, Rose, and Greene (2005) demonstrate that under this technique, attribute levels are balanced and it ensures that preference parameters are well-estimated. Following the code developed by Aizaki (2012), a total number of 9 different choice sets were obtained. Figure 4.1 shows an example of a choice set.

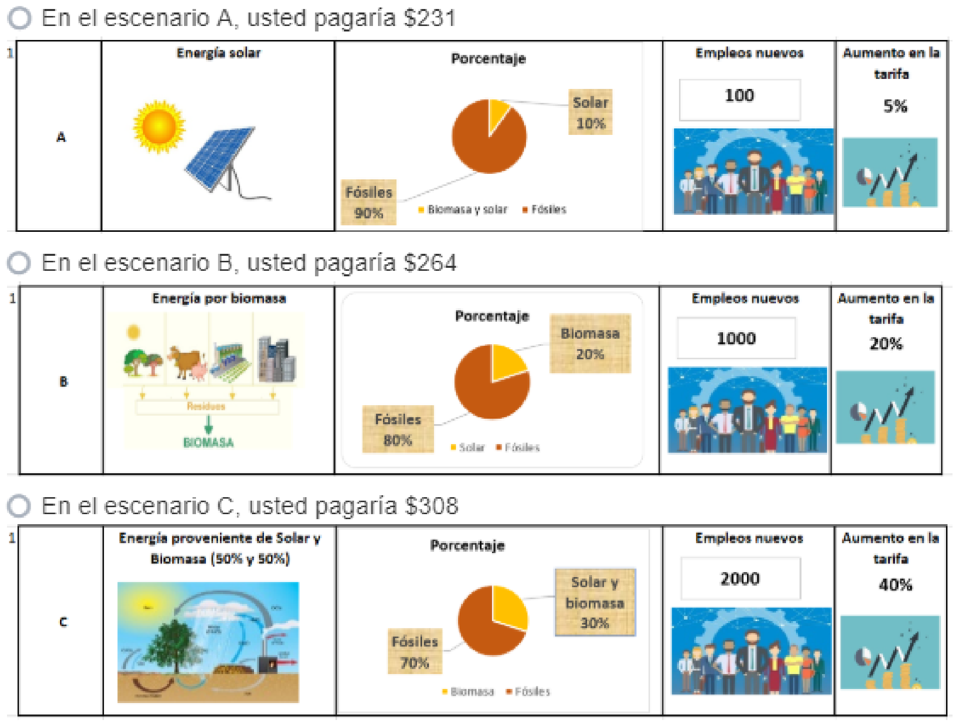

Figure 4.1: Example of choice set
Source: Own elaboration

From the way the attributes and levels were choose in the design of the CE, the utility that and individual n derives from choosing alternative i in choice scenario j is given as follows:

$$U_{nij} = \alpha_{nij}\text{es}_{nij} + \beta_{nij}\text{ep}_{nij} + \gamma_{nij}\text{nj}_{nij} + \delta_{nij}\text{price}_{nij} + \epsilon_{nij} \tag{4.1}$$

$$n = 1, ...N$$

$$i = 1, 2, 3$$

$$j = 1, ...9$$

where the subscript n represents the index of the individual, subscript j represents choice situations, subscript i represents the three distinct levels of the particular attribute and ϵ_{nij} represents the stochastic disturbance term representing characteristics unobservable by the researcher. Variables “es” , “ep”, and “nj” represent the attributes of energy source, energy percentage and new jobs, respectively.

It is expected that individuals value positively new employments and greater percentage participation of renewable energy. The coefficient for price is expected to be negative. The only attribute where there are not expected values regarding the most proffered level is for the energy source attribute. From these assumptions, the base level for the attribute energy percentage will be 10% and the base level for the jobs attribute will be one hundred. It is also expected that the real price sample will show greater response to the price attribute.

Two distinct questionnaires were made to test whether people react differently when more information about the advantages of renewables is given. One type of questionnaire included a paragraph which informed the contestant the advantages in energetic sovereignty that renewable energies may imply, telling them that currently half of the electricity produced in Mexico comes from natural gas and that 85% of the total national demand of natural gas is imported. This information was accompanied of graphic 4.2, which depicted the evolution of national production and imports of natural gas in the 2010-2017 period.

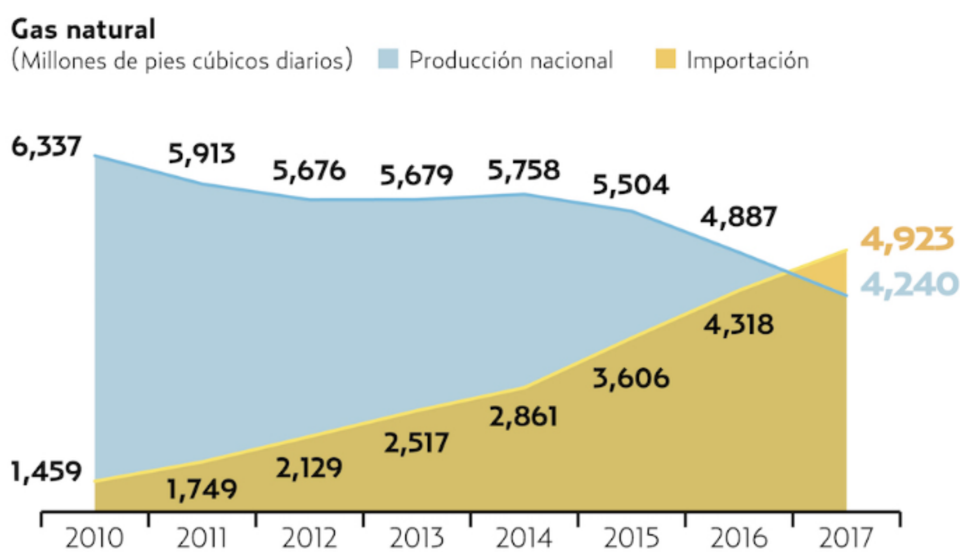

Figure 4.2: Treatment Image
Source: Arias, 2018

Also, to test if different preferences occurred when people are faced with a real price versus a recalled price of their electric bill, and answer other research question, it was decided to gather half of the data in a CFE pay station. Since in these pay stations people are carrying their electric bill, either electronic or printed, they should know the exact amount of their electric bill. Pay stations of CFE are typically located in some commercial plazas. For this reason, half of the sample was collected in commercial plazas. Thus, the sample is divided into two groups, one which responds with a real price, and another which does not.

It is useful to think the data sample divided by two distinct categories: treatment and control; real price and recalled price. First, let us assume our data sample as a whole rectangle, divided by two rows where the upper row of the rectangle corresponds to the control group and the lower half of the rectangle corresponds to the treatment group.

Control Group
Treatment Group

Secondly, the same rectangle is divided by two columns, the left column corresponding to the real price part of the sample, and the right column represents the recalled price part of the sample.

Recalled Price Amount	Real Price Amount

The price attribute can be managed as a categorical variable or as a continuous variable. One of the main advantages of the questionnaire design is that the respondent faced the election of the alternatives with his own real price or his own recalled price. Thus, the choice experiment provided individual price levels for every alternative in every choice set. This research will treat the price attribute as continuous, since it will allow us to obtain the willingness to pay for every level attribute. Questionnaires can be consulted in Vázquez-Pérez, Joel Tonatiuh (2019).

Chapter 5

Data

Target respondents were adults whose residence is in the Aguascalientes State and responsible for paying their residential electric bill. Questionnaires were administered face to face by a single interviewer which selected one type of questionnaire and approached randomly to a given place. Questionnaires were collected from mid April to early June 2019. Table 5.1 provides a summary statistics of the sample.

Table 5.1: Sample Characterization

Variable	**Whole Sample N=566**		**Population**
Gender			
Male	47%		48.8%
Female	53%		51.2%
Age			
<35	30%		44%
35-50	36%		30%
50<	34%		26%
Schooling			
Primary	23.3%		49.64%
Secundary	33.6%		23.32%
Post-secundary	43.1%		24.29%
Average household income (MXN)			
Income levels for sample:		Income levels for population:	
>8,000	26.27%	<7,895	30%
8,000-15,000	35.66%	9,747-13,531	30%
15,000-23,000	18.77%	16,309-19,818	20%
23,000-35,000	10.77%	25,736	10%

Source: Own elaboration

The size of the whole sample is 566. It has to be pointed that a single observation will represent in the estimation 27 observations. This is because every respondent made 9 choices consisted of three alternatives each. The data base can be consulted in Vázquez-Pérez, Joel Tonatiuh (2019).

Chapter 6

Results and Discussion

Following equation 4.1, eight models have been estimated. The first two models compare the coefficients for the respondents with the real price amount versus the respondents with the recalled price amount in the whole control sample. The coefficients estimation results of these two models are shown in table 6.1.

Table 6.1: Real Price vs Recalled Price. Control group sample

	Recalled Price	Real Price
election		
mix	0.186*	0.345***
	(0.0960)	(0.100)
solar	0.577***	0.756***
	(0.0934)	(0.0977)
30%	0.779***	0.710***
	(0.0936)	(0.0963)
20%	0.195**	0.0201
	(0.0967)	(0.100)
2000jobs	1.152***	0.846***
	(0.0962)	(0.0976)
1000jobs	0.635***	0.305***
	(0.0983)	(0.101)
price	-1.087***	-1.408***
	(0.0724)	(0.0828)
N	3510	3321
log likelihood	-1719.3721	-1592.5631
AIC	3452.744	3199.126
BIC	3495.888	3241.882

Base level for type of energy: Biomass
Base level for energy percentage: ten percent
Base level for number of jobs: 100 jobs
Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Source: Own elaboration

Results in table 6.1 show signs and directions as expected: higher levels of renewable energy share and jobs present higher coefficients than lesser levels. Also, the price attribute is negative. Regarding the energy source attribute, results indicate that solar energy is the most preferred renewable energy and biomass the least preferred. Because of this, the model was re-estimated with biomass assigned as the base level for the energy source attribute. Also, as expected, the real price sample has a stronger reaction to the price level. To asses the differences in the reaction to the price attribute within these groups, table 6.2 show the average marginal effect (AME) and the marginal effect at the mean (MEM) of the price attribute:

Table 6.2: Marginal effects for the price attribute. Control Sample

Marginal Effects	Control Sample	
	Real Price	**Recalled Price**
AME Price	-0.0743914	-0.0979533
	(.0048)	(.00398)
Conf. Int	(-.0838474, -.0649355)	(-0.1057574, -.0901491)
MEM Price	-0.0059353	-0.021597
	(.0018)	(.005)
Conf. Int	(-.0096528,-.0022177)	(-.032632, -.010562)

Standard errors in parentheses

Source: Own elaboration

From the confidence intervals, it is noted that there in not a statistically difference in the average marginal effect, but the difference exist in the marginal effect at the mean. Thus, a difference in the reaction to price between the real price and recalled price groups within the control sample exist.

Now, table 6.3 reports the estimation coefficients for the real price group respondents versus the recalled price respondents, within the treatment whole sample:

Table 6.3: Real Price vs Recalled Price. Treatment sample

	Recalled Price	Real Price
election		
mix	0.0655	0.0998
	(0.0956)	(0.101)
solar	0.458***	0.579***
	(0.0928)	(0.0982)
30%	0.495***	0.757***
	(0.0927)	(0.0993)
20%	0.0423	0.310***
	(0.0957)	(0.102)
2000jobs	0.807***	0.834***
	(0.0946)	(0.0991)
1000jobs	0.430***	0.253**
	(0.0967)	(0.102)
price	-1.184***	-1.490***
	(0.0818)	(0.0896)
N	3375	3213
log likelihood	-1716.6455	-1539.5128
AIC	3447.291	3093.026
BIC	3490.16	3135.55

Base level for type of energy: Biomass
Base level for energy percentage: ten percent
Base level for number of jobs: 100 jobs
Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Source: Own elaboration

First, it is noted that for the recalled price group ant the real price group within the treatment sample, the mix attribute-level is not significant and solar energy is the most preferred energy source as before. Also as before, higher levels of higher levels of renewable energy share and jobs are more preferred than lesser levels. The real price group shows a higher valuation for the attribute-levels of share of renewable energy than the recalled price group. For the recalled price group, the attribute-level of 20% energy share is not significant. Valuation towards the attribute-levels of jobs are of similar magnitude for both groups and, as expected, the real price sample has a stronger reaction to the price attribute. Table 6.4 shows the AME and MEM for the recalled price group and the real price group within the treatment sample:

Table 6.4: Marginal effects for the price attribute. Treatment Sample

Marginal Effects	**Treatment Sample**	
	Real Price	**Recalled Price**
AME Price	-0.0845995 (.0064)	-0.0801944 (.0059)
Conf. Int	(-.09716, -.072036)	(-0.0918864, -.0685024)
MEM Price	-0.0043557 (.00151)	-0.0170174 (.0046)
Conf. Int	(-.0073217,-.0013897)	(-.0261114, -.0079235)

Standard errors in parentheses
Source: Own elaboration

The confidence intervals for the AME for both groups intersect, but the confidence intervals for the MEM do not. This suggest that there is a difference in the reaction towards the price attribute in both groups.

Now, table 6.5 displays the WTP for all atttribute levels for both the real price and recalled price groups within the control group sample and the treatment group sample:

Table 6.5: WIllingness to Pay for Attributes. Treatment and Control Samples

Attribute	**Control Group**			**Treatment group**		
	Real Price	**Recalled Price**	**t-test**	**Real Price**	**Recalled Price**	**t-test**
mix	24.49 (7.2)	17.15 (8.87)	0.40	0	0	-
solar	53.66 (7.36)	53.04 (9.08)	0.00	38.84 (6.84)	38.66 (8.166)	0.00
30%	50.43 (7.2)	71.63 (9.05)	0.91	50.79 (7.08)	41.83 (8.21)	0.22
20%	0	17.98 (8.95)	3.86**	20.8 (6.9)	0	7.59***
2000jobs	60.05 (7.46)	105.97 (10.7)	3.25*	56 (7.16)	68.17 (8.96)	0.27
1000jobs	21.66 (7.2)	58.42 (9.63)	6.40 ***	16.93 (6.9)	36.29 (8.45)	2.43

t-test null hyphothesis: equal values
Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Source: Own elaboration

Within the control group sample, the WTP is statistically different for the 20% attribute-level of share of renewable energy and for the welfare attributes of jobs. The real price group shows a lesser WTP for these attributes. Making the comparisons in WTP within the treatment group, the results suggest that there are not statistically significant differences in the WTP amounts for almost all attributes in the real price and recalled price groups. The only attribute-level that showed differences in the WTP was the 20% attribute-level. This is because this attribute-level was not significant for the recalled price group and thus, its WTP is zero.

We are now in conditions to discuss the differences in the valuation that one individual who knows the real amount of his electric bill has versus another individual who just recalls it. For the control group sample, the real price respondents express lesser WTP for the welfare attributes and one environmental one. This lead us to think that people are reluctant to pay more in a situation when their income has just decreased by paying their electric bill. For the treatment group sample, there are not differences in the WTP for individuals who know their real amount of the electric bill and one who does not (excepting the 20% attribute-level, which was not significant for the recalled price group). This result suggest that the treatment had the effect of canceling the reluctance to pay more that an individual who just paid its electric bill shows in the control group when no additional information is given.

The way in which these four models were presented was to asses the differences in the WTP that arise when an individual knows the real amount of its electric bill and one who does not. The next four models aim to analyse the differences that the treatment had in the respondents. In this sense, table 6.6 displays the estimation results of the whole real price sample divided in the treatment group and the control group:

Table 6.6: Treatment Group vs Control Group. Real Price

	Treatment Group	Control Group
election		
mix	0.0998	0.345***
	(0.101)	(0.100)
solar	0.579***	0.756***
	(0.0982)	(0.0977)
30%	0.757***	0.710***
	(0.0993)	(0.0963)
20%	0.310***	0.0201
	(0.102)	(0.100)
2000jobs	0.834***	0.846***
	(0.0991)	(0.0976)
1000jobs	0.253**	0.305***
	(0.102)	(0.101)
price	-1.490***	-1.408***
	(0.0896)	(0.0828)
N	3213	3321
log likelihood	-1539.5128	-1592.5631
AIC	3093.026	3199.126
BIC	3135.55	3241.882

Base level for type of energy: Biomass
Base level for energy percentage: ten percent
Base level for number of jobs: 100 jobs
Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Source: Own elaboration

In these two models, it is seen that, as before, higher levels of the attributes are more preferred than lesser levels. Not all coefficients are significant: the attribute-level of mix is not significant for the treatment group and the same happens for the 20% attribute-level in the control group. The price attribute is negative, but it was expected that it would be lesser for the control group and this is not the case. Nevertheless, the difference in magnitude is minimal. As before, the next table 6.7 presents the AME and MEM for the price attribute in both groups:

Table 6.7: Marginal effects for the price attribute. Real Price Sample

Marginal Effects	**Real Price**	
	Treatment Group	**Recalled Price**
AME Price	-0.0743914 (.00482)	-0.0845995 (.0064)
Conf. Int	(-.0838474, -.0649355)	(-0.0971622, -.0720367))
MEM Price	-0.0059353 (.0018)	-0.0043557 (.00151)
Conf. Int	(-.0096528,-.0022177)	(-.0073217,-.0013897)

Standard errors in parentheses

Source: Own elaboration

For both the AME and MEM of the price attribute, the confidence intervals for the treatment group and the control group intersect, suggesting that there are no differences in the marginal effects of the price for both groups.

The last two models compare the coefficients for the treatment group with the control group in the whole recalled price sample. Results are displayed in table 6.8.

Table 6.8: Treatment Group vs Control Group. Recalled Price

	Treatment Group	Control Group
election		
mix	0.0655	0.186*
	(0.0956)	(0.0960)
solar	0.458***	0.577***
	(0.0928)	(0.0934)
30%	0.495***	0.779***
	(0.0927)	(0.0936)
20%	0.0423	0.195**
	(0.0957)	(0.0967)
2000jobs	0.807***	1.152***
	(0.0946)	(0.0962)
1000jobs	0.430***	0.635***
	(0.0967)	(0.0983)
price	-1.184***	-1.087***
	(0.0818)	(0.0724)
N	3375	3510
log likelihood	-1716.6455	-1719.3721
AIC	3447.291	3452.744
BIC	3490.16	3495.888

Base level for type of energy: Biomass
Base level for energy percentage: ten percent
Base level for number of jobs: 100 jobs
Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$
Source: Own elaboration

As before, there are no differences in the signs and orders of the coefficients: coefficients of higher levels of the attributes present a higher magnitude than lesser levels. The mix attribute-level and the 20% share of energy were not significant in the treatment group. The price attribute is slightly lower in the treatment group than in the control group. Table 6.9 shows the AME and MEM of the price attribute for the treatment group and the control group within the recalled price sample:

Table 6.9: Marginal effects for the price attribute. Recalled Price Sample

Marginal Effects	Recalled Price	
	Treatment Group	Control Group
AME Price	-0.0979533 (.00398)	-0.0801944 (.00596)
Conf. Int	(-.1057574, -.010562)	(-0.0918864,-.0685024)
MEM Price	-0.021597 (.00563)	-0.0170174 (.00463)
Conf. Int	(-.032632,-.010562)	(-.0261114,-.0079235)

Standard errors in parentheses

Source: Own elaboration

Similar to the last two models, the confidence intervals for the AME and MEM for both the treatment group and the control group intersect, suggesting that there are not statistically significant difference in the marginal effects of the price for both groups.

Table 6.10 displays the differences in willingness to pay for each level attribute, comparing the treatment and control groups within the real price and recalled price samples:

Table 6.10: Willingness to Pay for Attributes. Real Price and Recalled Price Samples

Attribute	Real Price			Recalled Price		
	Treatment	Control	t-test	Treatment	Control	t-test
mix	0	24.5 (7.20)	7.03***	0	17.15 (8.88)	4.68**
solar	38.84 (6.84)	53.66 (7.36)	0.63	38.67 (8.17)	53.04 (9.09)	0.36
30%	50.8 (7.08)	50.42 (7.20)	0.00	41.83 (8.21)	71.64 (9.50)	1.45
20%	20.8 (6.91)	0	9.46***	0	18 (8.95)	3.51*
2000jobs	56 (7.16)	60.05 (7.46)	0.04	68.17 (8.97)	105.97 10.70)	1.5
1000jobs	17 (6.90)	21.66 (7.20)	0.21	36.3 (8.45)	58.42 (9.64)	1.58

t-test null hypothesis: equal values

Standard errors in parentheses

*** $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Source: Own elaboration

As before, we are now in position to analyse the effect of the treatment on the WTP. Table

6.10 shows that the differences lies in the attribute-level of mix and 20% share. Regarding the attribute-level of mix, the results show that the treatment had the effect of eliminate the valuation towards this attribute. This could mean that, given additional information about the advantages of renewables, the consumer turns its full valuation regarding the source of renewable energy to solar energy. With respect to the 20% attribute level of renewable share, the results show mixed results. For the real price sample, the treatment had the effect of making this attribute significant and thus, there is a WTP for it. But the contrary happens within the recalled price sample: the treatment had the effect of nullify the valuation towards this attribute-level. At the light of these results, it can be said that the effect that the treatment had over the 20% attribute level is inconclusive. This results are consistent with the fact that the marginal effects show no differences between these groups. Thus, the only effect that the treatment had is on the mix energy source attribute.

Chapter 7

Conclusions

Discomposing the attributes associated with an investment strategy related to the promotion of renewable energy by the residential sector, this research aimed to estimate the valuation that consumers of Aguascalientes assign to this environmental good. The data analysis was consistent in showing that there is a positive valuation towards the environmental and welfare attributes associated. From these results, we can confidently declare that there is a positive valuation towards electric residential renewable energy in Aguascalientes.

The data was also consistent in revealing solar energy as the preferred energy source by the consumers. It is interesting to notice that in this sense, consumers from Aguascalientes do not differ from their foreign counterparts (Gracia, Barreiro-Hurlé, and Pérez y Pérez, 2012; Borchers, Duke, and Parsons, 2007; Cicia *et.al.* 2012; Vecchiato and Tempesta, 2015). Another resemblance to foreign preferences is in the fact that biomass is the least preferred source (Gracia, Barreiro-Hurlé, and Pérez y Pérez, 2012; Borchers, Duke, and Parsons, 2007; Vecchiato and Tempesta, 2015)

Another consistency lies in the valuation towards the welfare attributes. In all model specifications, the WTP for the jobs attribute is higher than the environmental attributes. This finding clearly suggest that economic concerns are higher than environmental concerns. The result is quite interesting under the light of the conflicts of the current energy policy with the environmental goals established in the ETL. This result may suggest that the goals of the ETL may be given up in favour of welfare attributes since people valuate them more and thus, opposition to the new policy is not expected to be a changing factor.

The comparison on how people react when taking in a situation with a real price versus a recalled price and the differences when having more information, reveals that consumers assign a higher value to welfare attributes that environmental attributes. The differences in the sample who knows his electric bill and those who do not are significant in the welfare attributes, suggesting again that economic concerns are higher than environmental concerns. The effect of the treatment by itself is inconclusive, but when comparing the WTP of the respondents who know the real amount of the electric bill versus the respondents who just recall it, the former express WTP similar to those who doesn't and are in the control sample. This could suggest that, for the treatment to have significance, it should be accompanied with additional information to the respondent. In this regard, we can conclude that, in order to induce a change of valuation of a consumer, the set of information given to him should not be limited.

Although bounded to welfare attributes, the finding that people react different when confronted with a real price situation versus a recalled price situation, may imply a modest contribution to the choice experiment method in the sense that researchers should take this into consideration because typically when applying the method, people make their hypothetical decisions with a price number that is recalled and not real. This would mean that the environmental good studied may present an overrated valuation.

From the results of this research, it is possible to obtain a demand curve for residential solar energy. Each sampled decision maker that choose the solar energy alternative revealed his willingness to pay for a given quantity of energy. Thus, we have a price and quantity for every one of these individuals, which represents a household. The sampled decision makers has some weight associated with him, w_m, representing the number of households similar to him in the population. If the sample is random, then w_m is the same for all n. Multiplying the weight with the quantity of energy and then summing for all individuals, a demand curve is obtained.

This study is, to the best of my knowledge, the first to demonstrate that residential renewable energy is positively valued by households for the Mexican case. Nevertheless, one should consider these results with caution. The sample showed some differences in educational and income levels within the treatment and control groups and the distinct price groups. The literature reviewed was consistent in showing that socioeconomical characteristics of consumers are determinant in explaining heterogeneity in preferences (Gracia, Barreiro-Hurlé, and Pérez y Pérez, 2012; Kim, Park, and Lee, 2018; Cicia *et.al.* 2012; Yoo and Ready, 2014; Alberini *et.al.* 2018; Susaeta *et.al.* 2011; Kosenius and Ollikainen, 2013; Bergmann, Hanley, and Wright, 2006). Thus, further research should include the analysis of valuation the effect of these socioeconomical individual characteristics.

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Bibliography

Aizaki, H. (2012). “Basic Functions for Supporting an Implementation of Choice Experiments in R”. *Journal of Statistical Software* 50.c02.

Alberini, A., Bigano, A., Ščasný, M., and Zvěřinová, I. (2018). “Preferences for Energy Efficiency vs. Renewables: What Is the Willingness to Pay to Reduce CO2Emissions?” *Ecological Economics* 144.October 2016, pp. 171–185.

Arias, A. (2018). “https://heraldodemexico.com.mx/mer-k-2/mexico-vive-una-situacion-critica-por-gas-natural/”. *El Heraldo de México*.

Bergmann, A., Hanley, N., and Wright, R. (2006). “Valuing the attributes of renewable energy investments”. *Energy Policy* 34.9, pp. 1004–1014.

Borchers, A. M., Duke, J. M., and Parsons, G. R. (2007). “Does willingness to pay for green energy differ by source?” *Energy Policy* 35.6, pp. 3327–3334.

Cicia, G., Cembalo, L., Del Giudice, T., and Palladino, A. (2012). “Fossil energy versus nuclear, wind, solar and agricultural biomass: Insights from an Italian national survey”. *Energy Policy* 42, pp. 59–66.

Farhar, B. (1996). “Willingness to pay for electricity from renewable energy”. *Contract* September.

Gracia, A., Barreiro-Hurlé, J., and Pérez y Pérez, L. (2012). "Can renewable energy be financed with higher electricity prices? Evidence from a Spanish region". *Energy Policy* 50, pp. 784–794.

Hensher, D. A., Rose, J. M., and Greene, W. H. (2005). *Applied Choice Analysis: A Primer*. Cambridge University Press.

INEEC (2018). "Inventario Nacional de Emisiones de Gases y Compuestos de Efecto Invernadero".

IRENA (2015). "Renewable Energy Prospects: Mexico". *REmap 2030* May, p. 106.

Kim, J., Park, S. Y., and Lee, J. (2018). "Do people really want renewable energy ? Who wants renewable energy ?: Discrete choice model of reference-dependent preference in South Korea". *Energy Policy* 120.April, pp. 761–770.

Kosenius, A. K. and Ollikainen, M. (2013). "Valuation of environmental and societal trade-offs of renewable energy sources". *Energy Policy* 62, pp. 1148–1156.

Lancaster, K. J. (1966). "A New Approach to Consumer Theory". *Journal of Political Economy* 74.2, pp. 132–157.

Longo, A., Markandya, A., and Petrucci, M. (2008). "The internalization of externalities in the production of electricity: Willingness to pay for the attributes of a policy for renewable energy". *Ecological Economics* 67.1, pp. 140–152.

Ma, C., Rogers, A. A., Kragt, M. E., Zhang, F., Polyakov, M., Gibson, F., Chalak, M., Pandit, R., and Tapsuwan, S. (2015). "Consumers' willingness to pay for renewable energy: A meta-regression analysis". *Resource and Energy Economics* 42, pp. 93–109.

Murakami, K., Ida, T., Tanaka, M., and Friedman, L. (2015). "Consumers' willingness to pay for renewable and nuclear energy: A comparative analysis between the US and Japan". *Energy Economics* 50, pp. 178–189.

Patricia A. Editor, C., Boyle, K., and Brown, T. (2003). “A Primer on Nonmarket Valuation”.

SENER. “SENER, 2018”.

Silva Ontiveros, L., Munro, P. G., and Melo Zurita, M. d. L. (2018). “Proyectos de Muerte: Energy justice conflicts on Mexico’s unconventional gas frontier”. *Extractive Industries and Society* 5.4, pp. 481–489.

Soliño, M., Farizo, B. A., Vázquez, M. X., and Prada, A. (2012). “Generating electricity with forest biomass: Consistency and payment timeframe effects in choice experiments”. *Energy Policy* 41, pp. 798–806.

Sovacool, B. K. and Dworkin, M. H. (2014). *Global Energy Justice: Problems, Principles, and Practices*. Cambridge University Press.

Sundt, S. and Rehdanz, K. (2015). “Consumers’ willingness to pay for green electricity: A meta-analysis of the literature”. *Energy Economics* 51, pp. 1–8.

Susaeta, A., Lal, P., Alavalapati, J., and Mercer, E. (2011). “Random preferences towards bioenergy environmental externalities: A case study of woody biomass based electricity in the Southern United States”. *Energy Economics* 33.6, pp. 1111–1118.

Train, K. E. (2003). *Discrete choice methods with simulation*. arXiv: `arXiv:1011.1669v3`.

Vecchiato, D. and Tempesta, T. (2015). “Public preferences for electricity contracts including renewable energy: A marketing analysis with choice experiments”. *Energy* 88, pp. 168–179.

Vázquez-Pérez, Joel Tonatiuh (2019). *Encuesta de Preferencias por Energía Renovable en la zona metropolitana de la ciudad de Aguascalientes.* Unpublished data base. June 2019. dta format.

Yoo, J. and Ready, R. C. (2014). “Preference heterogeneity for renewable energy technology”. *Energy Economics* 42, pp. 101–114.