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OFFICIAL MASTER'S DEGREE IN INDUSTRIAL ENGINEERING

MASTER THESIS

EXPERIMENTAL DESIGNS TO EVALUATE CONSUMER'S PREFERENCES RELATED TO ENERGY PROCUREMENT AND THE ADOPTION OF LOW-CO_2 TECHNOLOGIES

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Madrid

January 2023

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"Experimental designs to evaluate consumer's preferences related to energy procurement and the adoption of low-CO_2 technologies"

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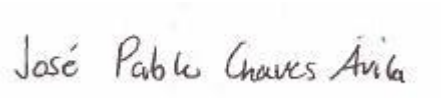

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DISEÑOS EXPERIMENTALES PARA EVALUAR LAS PREFERENCIAS DE LOS CONSUMIDORES EN RELACIÓN CON EL SUMINISTRO DE ENERGÍA Y LA ADOPCIÓN DE TECNOLOGÍAS BAJAS EN CO_2

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RESUMEN DEL PROYECTO

Introducción

Durante el último año, el precio de la electricidad en los mercados mayoristas ha alcanzado niveles de récord, afectando a millones de consumidores. En España, muchos consumidores, especialmente los acogidos al PVPC (Precio Voluntario para el Pequeño Consumidor) han visto cómo sus facturas se disparaban, puesto que el PVPC depende del precio del mercado mayorista. Sin embargo, falta claridad en cuanto a la percepción sobre los precios de la electricidad por los consumidores, cómo los entienden y cuáles son los principales ejes que empujan a escoger una comercializadora de electricidad u otra.

Aunque las señales económicas son un factor esencial en el proceso de toma de decisiones, los patrones de comportamiento suelen ser dejados de lado. Esta circunstancia es descrita como imprudencia por varios análisis que afirman que los hogares (como pieza fundamental en la transición energética) son muchas veces estudiados como elementos puramente racionales que toman decisiones basados en figuras numéricas, cuando la realidad es mucho más compleja.

La motivación de este proyecto es entender los principales factores que afectan el proceso de toma de decisiones en temas relacionados con la electricidad en los hogares españoles. Específicamente, los cuatro elementos a examinar son cómo se presentan las alternativas (*framing*), sostenibilidad (y su impacto en la disposición a pagar), aversión a pérdidas, aversión al riesgo y disposición a cambiar hábitos.

Metodología

Para obtener los datos del análisis de la situación actual en España, un diseño cuasi-experimental se administra mediante una encuesta. El proceso de diseño y estudio de la encuesta se puede condensar en los siguientes pasos:

1. Identificación de los elementos a examinar en la encuesta. Determinar qué percepciones y comportamientos específicos de los encuestados son de interés.
2. Determinación de los tests de hipótesis estadísticas. Establecer qué tests se aplican a la muestra y definir un umbral para considerar las hipótesis nulas aceptables.
3. Establecimiento de controles de validez interna y externa. Entender cómo factores externos pueden afectar el resultado de las respuestas a la encuesta y si los resultados son aplicables sobre la población, distinguiendo si la extrapolación a la población española es factible.
4. Definición del experimento. Estimar el número de encuestados necesarios para alcanzar los niveles de potencia y precisión de los tests estadísticos, definir público objetivo, diseñar las preguntas para la encuesta, lanzar y enviar el experimento.
5. Análisis de la muestra. Incluir tratamiento previo de datos y analizar los resultados de la encuesta con tests estadísticos. Una vez se derivan resultados, se extraen conclusiones.

La aplicación de la metodología al caso de estudio se traduce en:

1. Identificación de los elementos a examinar en la encuesta.
    a. Encuadre sostenible. Cerca de la mitad de los encuestados reciben una presentación positiva y el resto, reciben presentación negativa. La presentación positiva muestra una situación optimista (alto porcentaje de renovables en el sistema y expectativas de crecimiento), mientras que la negativa describe circunstancias pesimistas (un puñado de compañías emitiendo la mayoría de las emisiones de CO_2, dificultad para impactar el panorama general como consumidor individual). Tras leer el enunciado, el encuestado responde a una pregunta sobre su disposición a pagar un precio adicional por una tarifa eléctrica que asegura que las fuentes de generación que suministra son completamente renovables.
    b. Aversión a pérdidas. Definida como la función de utilidad que considera más pronunciadas las pérdidas que las ganancias, las cuestiones de la encuesta también se dirigen a la aversión a pérdidas y la influencia que otros factores demográficos tienen en ella. Uno de los objetivos de la encuesta es entender si los consumidores han considerado cambiar su comercializadora de electricidad, si piensan que podrían estar pagando menos por su factura y los obstáculos potenciales que pueden aparecer al tratar de cambiar de tarifa o de comercializadora para el consumo del hogar.
    c. Aversión al riesgo. La aversión al riesgo puede definirse como el miedo (o preferencia) irracional a la incertidumbre. La aversión al riesgo se trata también en la encuesta para verificar la comprensión de los encuestados en cuanto a tarifas fijas y variables y preferencias al escoger comercializadora. Los participantes reciben porcentajes de lo mínimo y máximo que acabarían pagando con la tarifa variable. La tarifa variable es

probabilísticamente más barata pero la factura final es independiente del consumidor.

d. Disposición a cambiar hábitos. El último elemento a examinar es la propensión de los consumidores a cambiar sus hábitos de consumo mediante un incentivo económico. Esta sección de la encuesta se enfoca en verificar la comprensión de los encuestados en cuanto a tarifas fijas y variables y las preferencias al escoger una tarifa de electricidad si esta es dependiente en los patrones de comportamiento del consumidor. La factura final en el caso variable depende de las horas de consumo.

2. Determinación de los tests de hipótesis estadísticas. Las hipótesis estadísticas incluyen:

    a. Encuadre sostenible: t-test y ANOVA.

    b. Aversión a la pérdida: Análisis en Componentes Principales para obstáculos relacionados y ANOVA.

    c. Aversión al riesgo. ANOVA.

    d. Disposición a cambiar hábitos: ANOVA, test de McNemar.

    Además, se calculan matrices de correlación para cada par de variables, incluyendo ρ de Spearman y p-valor.

3. Establecimiento de controles de validez interna y externa.

    a. Para validez interna: incluir controles de evasión de mortalidad experimental, ceguera de sujetos, adherencia al protocolo y controles estadísticos que verifiquen que la aleatorización se ha efectuado correctamente.

    b. Para validez externa: captación de participantes con distintas situaciones, analizando cómo de similar es la muestra a la población (conjunto de residentes en España).

4. Definición del experimento. Este paso incluye un estudio de los potenciales participantes y los canales de distribución de la encuesta, además del cálculo de tamaño mínimo de muestra. La cifra final requerida es 128 personas (64 para cada grupo de encuadre). Como el número final de encuestados es 246 (115 y 131 para cada grupo), se considera que se alcanzan los requisitos mínimos de tamaño muestral.

    Tras esto, se diseñan las preguntas específicas de la encuesta. Además de la sección de los cuatro elementos comentados (encuadre sostenible, aversión a la pérdida, aversión al riesgo y disposición a cambiar hábitos), se incluyen preguntas sobre el perfil del consumidor (tipo de tarifa, bono social, etc.) y características demográficas (edad, género, etc.).

5. Análisis de la muestra.

    a. Se codifican preguntas y respuestas.

b. Se realiza test de manipulación, test de aleatorización, efecto *priming*, medida de fiabilidad de la escala de actitud medioambiental y medida del *Common Method Bias*. Se determina que el test de manipulación excluye a los participantes que no han comprendido el encuadre, que la aleatorización se ha llevado a cabo correctamente (p-valores > 0.05) no existe efecto *priming* (p-valores > 0.05), la escala de actitud medioambiental muestra una fiabilidad adecuada (α de Cronbach = 0.758) y *Common Method Bias* no está presente (al realizar el Análisis en Componentes Principales, el primer componente explica sólo el 11,66% de la varianza).

c. Aplicación de los tests estadísticos.

Resultados

En primer lugar, en cuanto a la formulación enfatizando la perspectiva de sostenibilidad y la influencia en la disposición del consumidor a pagar, los resultados del t-test indican ($p = 0.044$) que hay cierta influencia en los grupos, puesto que aquellos que reciben el tratamiento negativo declaran estar dispuestos a pagar un 9% adicional en su factura por un suministro 100% renovable. Aquellos que reciben el tratamiento positivo tienden a responder que sólo pagarán un 3% o 6% adicional en su factura. Esto contradice estudios previos.

Al estudiar la correlación con otras variables, se encuentra que no hay más factores que influencien la disposición a pagar (todas las correlaciones muestran una ρ de Spearman > 0.3).

En segundo lugar, se observa en la muestra aversión a la pérdida, ya que alrededor de 1 de cada 4 personas (23%) que no han considerado cambiar su comercializadora en los últimos 12 meses piensa que podrían estar pagando una factura menor. Este fenómeno se ha observado por estudios previos. Más del 30% de aquellos que piensan que no podrían estar pagando una factura menor opinan que su compañía actual no les ha dado problemas y que confían en la compañía. En cambio, aquellos que creen que podrían estar pagando menos señalan su ignorancia sobre los tipos de tarifa (40%).

Un gran porcentaje de consumidores bajo el PVPC no creen que pudieran estar pagando una factura de electricidad menor. No se encuentran correlaciones sólidas ni moderadas entre aversión a pérdidas y variables demográficas. Tampoco se encuentra correlación sólida entre aversión a la pérdida y disposición a cambiar hábitos, como señalan otros estudios.

En tercer lugar, la aversión al riesgo se prueba en una pregunta. Los participantes deben escoger entre una tarifa fija y una variable. La probabilidad de que su factura final alcance una u otra cantidad es dada. Un consumidor puramente racional preferiría la tarifa variable, puesto que lo más probable es pagar una cantidad menor que la ofrecida por la fija. Sin embargo, los resultados muestran que sólo el 39% de los encuestados prefieren la tarifa variable. De nuevo, no se encuentran correlaciones sólidas ni moderadas al emparejar esta variable al resto, oponiéndose los resultados a estudios previos que señalan correlación entre aversión al riesgo y características demográficas. La única variable con

la que se puede considerar una correlación significativa es la disposición a cambiar hábitos, pero la ρ de Spearman no alcanza niveles que arrojen resultados concluyentes.

Por último, en la pregunta de disposición a cambiar hábitos, los encuestados deben escoger entre una tarifa fija y otra variable. En este caso, la variable depende de sus hábitos de consumo (la cantidad total a pagar en la factura es mayor o menor dependiendo de en qué periodos se consume). Más del 60% de los participantes escogen la tarifa variable como la opción preferida, es decir, 6 de cada 10 personas en la muestra declaran estar dispuestos a cambiar sus hábitos a cambio de un decremento en su factura de electricidad. Alrededor del 50% de los encuestados que prefieren la tarifa fija en la pregunta anterior cambian su respuesta a la tarifa variable en esta pregunta, implicando que la tarifa variable es la preferida cuando el resultado de la factura depende en el comportamiento del consumidor. De nuevo, no se encuentran correlaciones moderadas ni fuertes con el resto de variables. La única variable que muestra cierta influencia, como se comenta en el párrafo anterior, es la aversión al riesgo.

Conclusiones

Los resultados de la encuesta indican que:

- El encuadre sostenible tiene cierta influencia en la disposición a pagar un suministro eléctrico renovable.
- Cuando los encuestados deciden entre una tarifa fija o variable, se evita la tarifa variable cuando la factura depende de factores ajenos al control del consumidor, aunque sea probabilísticamente más barata que la fija. Sin embargo, la tarifa variable es la preferida cuando es el consumidor el que con su comportamiento puede reducir la cantidad de la factura final modificando sus hábitos de consumo.
- Las características demográficas como la edad o el género no parecen influenciar el proceso de toma de decisiones en cuanto a elecciones sobre electricidad en el hogar.

Entendiendo las limitaciones del proyecto y las nuevas potenciales dimensiones que futuro estudios pueden tratar, se añade una lista de puntos a considerar:

- Una de las principales causas de la falta de validez externa en algunos grupos surge de representación insuficiente de ciertos colectivos, en concreto, personas mayores de 74 años y consumidores cuyo nivel académico es igual o menor a la educación secundaria.
- La encuesta no se limitó a ningún tipo de consumidor. Sin embargo, para futuros estudios, puede ser beneficioso circunscribir la muestra objetivo a consumidores que pagan la factura de electricidad en su hogar o son los responsables de la elección de tarifa o comercializadora.
- Aunque el nivel académico y estado profesional eran elementos de la encuesta del presente proyecto, un mayor entendimiento de estos puede ser ventajoso. Específicamente, preguntar a los consumidores si su historial académico o profesional se relaciona con el sector de la electricidad.

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EXECUTIVE SUMMARY

Introduction

In the past year, price of electricity in wholesale markets has risen to record levels, affecting millions of consumers. In Spain, those consumers taken under the wing of the PVPC (Precio Voluntario para el Pequeño Consumidor or Voluntary Price for the Small Consumer) have seen how their bills skyrocketed, as PVPC depends on the prices of wholesale market. However, it is not clear how the perception of changes in price are digested by consumers and which are the main drivers when choosing an electricity retailer.

While the economics signals are an essential factor in the decision making progress, behavioral patterns are usually left aside and misunderstood. This circumstance is described as recklessness by many studies that claim households (as key players in the energy transitions) are usually seen as purely rational items that would make decisions based on financial figures, while reality is much more complex.

The motivation of this project is understanding the drivers behind the decision-making process in electricity-related topics in Spanish households. Specifically, the four elements to test are sustainable framing (and it impact in the willingness to pay), loss aversion, risk aversion and willingness to change habits.

Methodology

In order to obtain the inputs to analyze the current situation in Spain, a quasi-experimental design administered via a survey is carried out. The process to design and study the survey might be summarized in the following steps:

1. Identification of the elements to test in the survey. Determine which specific perceptions or behaviors by respondents are the outcomes of interest of the survey

2. Determination of statistical hypothesis tests. Establishing which tests will be applied to the gathered sample and defining a threshold to accept or reject null hypotheses.
3. Establishment of internal and external validity controls. Understanding how external factors might affect the outcome of responses in the survey and how applicable are conclusions to the population-wide extent, discerning if extrapolation to Spanish population is feasible or not.
4. Experiment definition. Estimating how many respondents are needed to achieve the levels of power and precision in statistical tests, targeting respondents, designing the questions for the survey and launching and sending the experiment
5. Sample analysis. Includes preliminary data treatment and control and analysis of results via statistical tests. Once the results are derived from the survey, conclusions are extracted.

The application of the methodology to the current case translates into the following:

1. Identification of the elements to test:
    a. Ecologically sustainable framing. Around half of the respondents receive a positive framing before answering a question and the rest receive a negative framing. Positive framing exposes an optimistic situation (high share of renewables in the system and expected growth) and negative framing exhibits pessimistic circumstances (a handful of companies emitting the majority of CO_2 emissions, difficulty to impact the bigger picture as a consumer). After reading the framed choice, respondents are asked about their willingness to pay for a more electricity tariff that assures the source is completely renewable.

    b. Loss aversion. Defined as a utility function which is steeper for losses than for gains, the questions in the survey target loss aversion and its interaction with other psychological and demographic factors. The aim in this survey is to understand if consumers have previously thought about changing electricity retailer, if they think they could be paying a cheaper bill and the potential obstacles that might appear when trying to change the tariff or retailer for the household consumption

    c. Risk aversion. Risk aversion might be defined as the irrational fear (or fanciness) of uncertainty. The risk aversion section in the survey is aimed to verify the comprehension of respondents regarding fixed and variable tariffs and the preferences when choosing an electricity tariff. Participants are given some percentages of how cheap and how expensive their bill could be. The final price is probabilistically cheaper but it is independent on them.

    d. Willingness to change habits. The last element to test is how prone consumers are to change their consumption habits with an economic incentive. The WTCH section in the survey is aimed to verify the comprehension of respondents regarding fixed and variable tariffs and the

preferences when choosing an electricity tariff if the final bill depends directly on their energy behavior. The variable tariff final payment might depend on the hours of consumptions and other swift behaviors.

2. Determination of statistical hypothesis tests. Hypothesis testing includes:

    a. Ecologically sustainable framing: t-test and ANOVA.

    b. Loss aversion: Principal Component Analysis for related obstacles and ANOVA.

    c. Risk aversion: ANOVA.

    d. Willingness to change habits: ANOVA, McNemar test.

    In addition to this, correlation matrices are calculated for every pair of variables. They include the Spearman's ρ and p-value.

3. Establishment of internal and external validity controls.

    - For internal validity: including experimental mortality avoidance controls, blinding of subjects, adherence to protocol mechanisms and statistical controls to establish randomization is correctly performed.

    - For external validity: targeting respondents with different backgrounds, analyzing how similar the sample is to population (Spanish residents).

4. Experiment definition. This step includes a study of the potential respondents and channels and calculation of the minimum sample size. The final figure is 128 required respondents (64 people for each framing group). As final number of respondents is 246 (115 and 131 for every group), it is considered minimum sample size requirements are met.

    After this, questions for the survey are designed. In addition to the four elements to test (sustainable framing, loss aversion, risk aversion and willingness to change habits), the survey includes questions about the consumer profile (type or tariff, bono social, obstacles, etc) and demographic features (age, gender, etc).

5. Sample analysis.

    a. Questions and answers are coded into variables and possible values.

    b. Manipulation check, randomization test, priming effect test, measure of the reliability of environmental attitude scale and measure of Common Method Bias are performed. It is determined that manipulation check excludes candidates that do not understand the framing, randomization is correctly performed (p-values for demographic variables and environmental attitude scale > 0.05), no priming effect takes place due to sustainable framing (it does not affect other variables, p-values > 0.05), the environmental attitude scale shows an adequate reliability (Cronbach's $\alpha = 0.758$) and Common Method Bias is not present (when performing a PCA of all variables, first Component explains only 11.66% of variance).

    c. Application of the statistical tests.

Results

First, regarding the sustainable framing and the influence on the consumer willingness to pay, the results of the t-Student indicate ($p = 0.044$) that there is some influence by the framing on the groups, as those who receive the negative treatment are more willing to pay an additional 9% price in their bill for a 100% renewable energy supply. In contrast, those who receive positive treatment tend to answer that they would pay only an additional 3% or 6% price in their bill. This contradicts previous research on the topic.

When studying the correlation to other variables, it is found that no other factors seem to influence the willingness to pay question (no correlation shows a Spearman's $\rho > 0.3$).

Secondly, loss aversion is observed in the sample, as around 1 of 4 people (23%) that have not considered changing electricity retailer in the past 12 months think they could be paying a cheaper electricity bill. This phenomenon has been observed by previous research. More than 30% of those that think they could not be paying a cheaper bill claim their current option has not given them any problems and they trust the company. In contrast, those who think they could be paying a cheaper electricity bill highlight the ignorance about types of tariffs (40%).

Focusing on PVPC consumers, a larger share think they could not be paying a cheaper electricity bill. No strong correlation of loss aversion is found when paired with demographic variables. No strong correlation is found either when paired with Willingness to Change Habits, which is suggested by previous research.

In the third place, the risk aversion is tested in one question: respondents have to choose between a fixed and a variable tariff. A probability of the possible outcomes of their bill is given. A purely rational consumer would prefer the variable tariff, as the probabilistic outcome of paying a cheaper bill is higher. However, results show that only 39% of the respondents prefer the variable tariff. Again, no moderate or strong correlation is found when pairing this variable to the rest, as opposed to previous studies that linked risk aversion attitudes with demographic features. The only variable that might have some correlation is the response tis the Willingness to Change Habits, but the Spearman's ρ is too low to extract firm conclusions.

In the case of Willingness to Change Habits, respondents have to choose between a fixed and a variable tariff. The variable tariff depends on their consumption habits (the final amount to pay might be higher or lower depending on the energy consumption periods). More than 60% of the respondents choose the variable tariff as the option they would prefer, meaning that 6 out of 10 people in the sample would be willing to change their habits in order to obtain a cheaper bill. Around 50% of the people who prefer a fixed tariff in the risk aversion question change to the variable tariff in this one, meaning a variable tariff is preferred when the outcome of the bill is dependent on consumer behavior. Again, no moderate or strong correlation is found when pairing this variable to the rest. The only variable that shows some influence is the response to the risk aversion.

Conclusions

The results of the experiment indicate that:

- Sustainable framing has some effect on the willingness to pay for 100% renewable energy by consumers.
- When respondents are given the choice to opt for a variable or fixed tariff, the variable tariff is avoided when the bill depends on something out of the consumer's control, even though it is probabilistically cheaper. However, the variable tariff is preferred when the consumer can decrease the final price by changing their consumption habits consuming energy at certain periods of time during the day).
- Demographic factors such as age, gender, etc. do not seem to influence the decision making process regarding electricity-related opinions.

Understanding the limitations of the project and the potential new dimensions future research might focus on, a list of points to address hereafter on the topic is presented below:

- One of the main issues regarding external validity of the survey comes from the insufficient representation of certain groups in the sample, namely people older than 74 years old and consumers whose higher educational level are primary or secondary studies.
- The survey presented in the current project was not limited to any consumer. However, for future studies, it might be beneficial to circumscribe the targeted sample to consumers that pay the bill in their household or are responsible for the choice of retailer or tariff.
- Even though the academic level and professional status are items of the survey presented in the current project, a deeper understanding of these might be advantageous. Specifically, asking consumers if their academic background or professional occupation is related to the electricity sector.

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Acronyms and abbreviations

Acronym/abbreviation	*Full name*
CCGT	Combined Cycle Gas Turbine
CNMC	Comisión Nacional de los Mercados y la Competencia- Spanish Regulator
CO_2	Carbon Dioxide
ETS	Emissions Trading System
EU	European Union
IEE	Impuesto Especial Sobre la Electricidad – Special Tax over Electricity
LCOE	Levelised Cost Of Electricity
NEMO	Nominated Electricity Market Operator
OCU	Organización de Consumidores y Usuarios – Consumers and Users Organization, Spanish independent organism
OMIE	Operador del Mercado Ibérico de Electricidad – Iberian NEMO
PVPC	Precio Voluntario para el Pequeño Consumidor – Regulated Price for Small Consumer
PNIEC	Plan Nacional Integrado de Energía y Clima – National Integrated Plan for Energy and Climate
REE	Red Eléctrica de España – Spanish TSO
SWTP	Stated Willingness To Pay
TSO	Transmission System Operator
WTCH	Willingness To Change Habits
WTP	Willingness To Pay

1. Introduction

In the past year, the price of electricity in wholesale markets has risen to record levels, affecting millions of consumers. In Spain, those consumers taken under the wing of the allegedly cheaper PVPC (Precio Voluntario para el Pequeño Consumidor or Voluntary Price for the Small Consumer) have seen how their bills skyrocketed, as PVPC depends on prices of wholesale market. However, it is not clear how the perception of changes in price are digested by consumers and which are the main drivers when choosing an electricity retailer.

Therefore, the goal of this project is to understand how demographic (age, academic level, gender, etc.) and psychological factors (sustainable framing, risk aversion, loss aversion, willingness to change habits) affect the decision making process regarding electricity tariffs and preferred retailer in Spanish households.

Previous research links a higher willingness to pay when a positive sustainable framing is applied (7) (8), and the relation between the loss aversion and risk aversion phenomena with demographic factors is included in previous studies (13) (14) (11). Other scholars point out that main obstacles to change consumption patterns in households are lack of information, administrative problems and complexity (15) (16) (17). The present study tries to find evidence to support or contradict previous research, while extracting conclusions that might be useful to policymakers.

This master thesis is structured in several sections.

First, a brief study of the main causes of price raises is presented to fully understand how certain circumstances are affecting energy markets and how they are reflected on final consumer's bills and behaviors.

Secondly, an experiment is carried out in order to study the perception of these consumers regarding the different alternatives in electricity retail and the changes in patterns or preferences that might have arisen in these past months. The experiment is administered in an online survey and the main elements to test are sustainable framing, loss aversion, risk aversion, willingness to change habits and the potential correlation of these with demographic factors such as age or gender. Results of this experiment are presented and some suggestions for information presentation in bills and policy design are added.

Lastly, the project includes conclusions and some proposals for future research on the topic.

2. State of the Art

In this chapter, the context and circumstances of the topic of this master's thesis are explained.

2.1. How tariffs work

In Spain, a residential consumer has two main options to choose in terms of electricity tariffs. The first one is the PVPC or Precio Voluntario para el Pequeño Consumidor, a last resort tariff defined in the Royal Decree 216/2014. It is a regulated tariff whose final price depends on several factors that are explained in this subsection. The second option is the free market, an alternative where both consumer and retailer reach an agreement to set a price for energy, the agreed prices can be dependent on the market or not, they can be fixed for the contracted period or variable. There is not a specific formulation for the price of a free market tariff.

2.1.1. PVPC: basic concepts

PVPC is the default tariff in Spain and it is applied to almost 11 million consumers, figure that represents 37% of consumers (18). It is offered by eight specific retailers in Spain ("comercializadoras de último recurso"/last resort retailers or "comercializadoras de referencia"/reference retailers). They are listed in Table 1:

Last resort retailer logo	*Name*	*Business group*
BASER Comercializadora de Referencia	Baser CoR	EDP
energíaXXI	Energía XXI	Endesa
Teramelcor	Teramelcor	Gaselec Diversificación
comercializador de referencia energético grupo chc	Corenergetico	CHC
Régsiti Comercializadora Regulada	Régsiti	Repsol
comercializadora regulada Grupo Naturgy	Gas & Power	Naturgy

Curenergía	Iberdrola
Energía Ceuta XXI	Endesa

Table 1. List of last resort retailers in Spain. 2022. Source: CNMC. (2022).

This regulated tariff can only be applied to consumers with a maximum voltage connection of 1 kV and a maximum power of 10 kW, meaning the distribution charges are applied according to 2.0TD tariff described in Circular 3/2020 by CNMC.

PVPC is critical for vulnerable consumers, as they can only ask for a social bonus o social aid ("bono social") if they accept PVPC as their tariff. This social bonus means a 25% discount over PVPC for vulnerable consumers and 40% for extremely vulnerable consumers[1]. The vulnerable status is obtained in the cases where the family budget falls below a basic threshold, a member of the family unit shows a certain level of disability, among other considerations[2].

2.1.2. How PVPC is formed

The PVPC is the sum of three terms: cost of energy production, access charges and retailer margin. The detailed definition of every one of these terms is explained in Royal Decree 216/2014.

Figure 1. How PVPC is formed, three components. Source: RD 216/2014. (2014).

Cost of energy production

The cost of energy production is the aggregation of several terms:

- Average price in day ahead and intraday market per hour. Iberian day ahead and intraday markets are marginal, meaning price is that of the last accepted bid. Sellers' bids are aggregated, buyers' bids are aggregated and the intersection is the marginal price. All sellers that bid for the marginal price or less receive the marginal price. All buyers that bid for the marginal price or more pay the marginal price. The rest of agents are not considered to be matched. Therefore, the most expensive technology covering demand sets the price for all the agents in the market for the given hour.

[1] As a temporary measure, from 27th October 2021 to 30th June 2022, discount percentages were modified to 60% and 70% instead of 25% and 40%, Royal Decree 23/2021.
[2] Royal Decree 897/2017, 6th October, to regulate vulnerable consumer definition, social bonus and other social guarantees for domestic consumers of electricity.

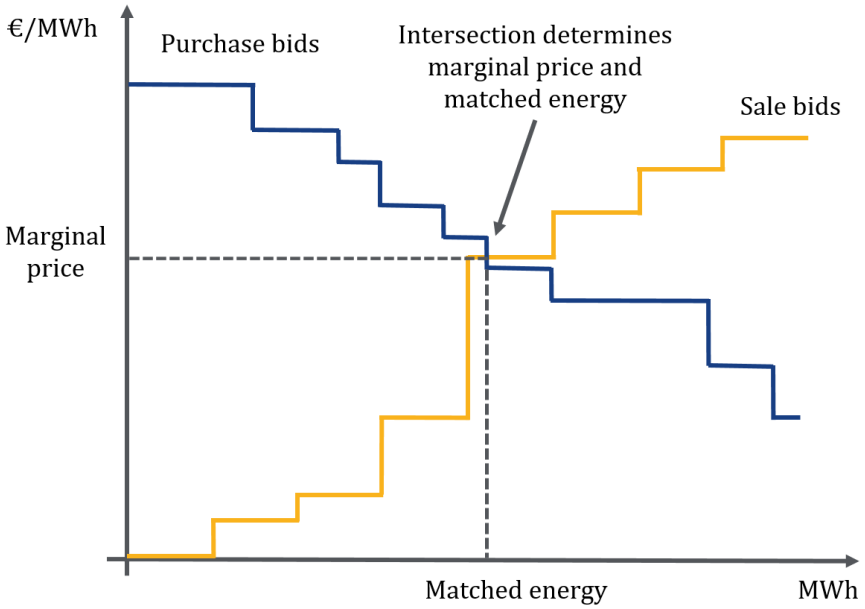

Figure 2. Marginal price settlement. Source: author's own preparation using information from CNMC. (2022).

- Ancillary services (energy programmed for balancing and the costs of other services to ensure a secure operation of the system).
- Other costs such as retribution to OMIE (NEMO, market operator), REE (TSO), capacity payments or interruptibility payments for industrial consumers.

Access tolls and charges

The access tolls and charges refer to network transmission and distribution charges. These charges have two components: power and energy.

The power term for 2.0TD is considered either peak or valley, while energy charges are classified in three categories: peak, flat or valley. The application hours slightly vary from the Peninsula, Balearic and Canary Islands to Ceuta and Melilla.

Figures for 2.0TD consumers regarding access charges for the year 2023 can be consulted in Resolution 21799 of 15th December 2022 by CNMC.

Retailer margin

Similar to the access charges, the retailer margin component can be divided into power and energy charges as well. Both power and energy retailer margins for PVPC tariffs are established by the Energy Ministry and aim to ensure to cover the costs for the last resort retailers and ensure a reasonable profit margin.

It is noteworthy to say that the final bill a consumer receives is not only the result of PVPC, as it also accounts for other costs and taxes.

Other costs include the rent of the electricity meter and measurement system.

Taxes include VAT (IVA, Impuesto sobre el Valor Añadido)[4] and the special tax over electricity (IEE, Impuesto Especial sobre la Electricidad)[5].

2.1.3. Free market

As previously mentioned, PVPC is the default tariff but the domestic consumer may choose to change to a "free market" tariff. In this type of engagement, the price might be fixed all year long, might have different values depending on the hour, might depend on wholesale market with dynamic pricing similarly to the PVPC… In other words, free market tariffs are calculated using different pricing mechanisms set by retailers. Note only limitation is that this pricing has to consider same access charges than PVPC.

It is estimated that in Spain, tariffs for around half a million households are calculated using a dynamic pricing strategy indexed to wholesale markets in the free market (18).

2.2. Recent events in the electricity market

As explained in Section 2.1. and displayed in Figure 2, wholesale market is marginal and therefore, the price is that of the last accepted bid. The generation technology that matches the last bid is therefore usually called "price setting" (20). It is very common in European market for that price setting generator to be gas, coal or lignite-fired generation technology.

As these fossil fuel technologies are the ones with highest bids, once they enter the market clearing, they set the marginal price. In the case of Spain, natural gas is especially important since coal and lignite-fired technologies are nowadays almost completely discarded due to sustainability constraints and high CO2 prices.

[4] Value Added Tax or IVA, usually set at 21%. Consumers with less than 10 kW enjoy a 10% IVA as a general rule, but temporarily set to 5% as specified in Royal Decree Law 06/2022 and Royal Decree Law 20/2022.

[5] Special Tax over Electricity or IEE, usually set at 5.11%, but lowered to 0.5% by Royal Decree Law 17/2021 and extended by Royal Decree Law 20/2022.

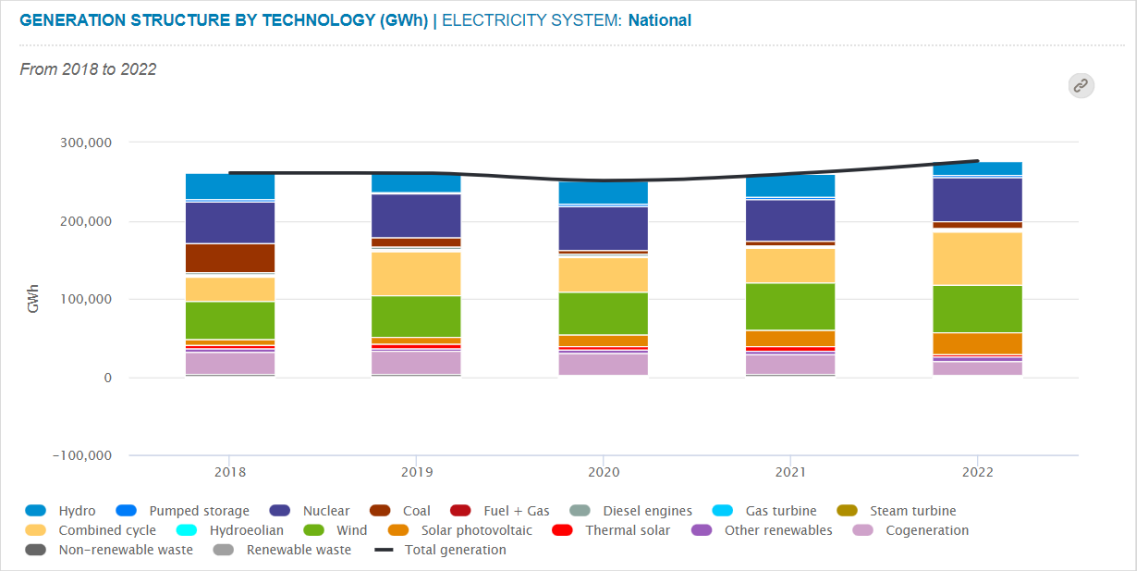

Figure 3. Annual electricity generation by source, Spain 2018 – 2022. Source: REE. (2023).

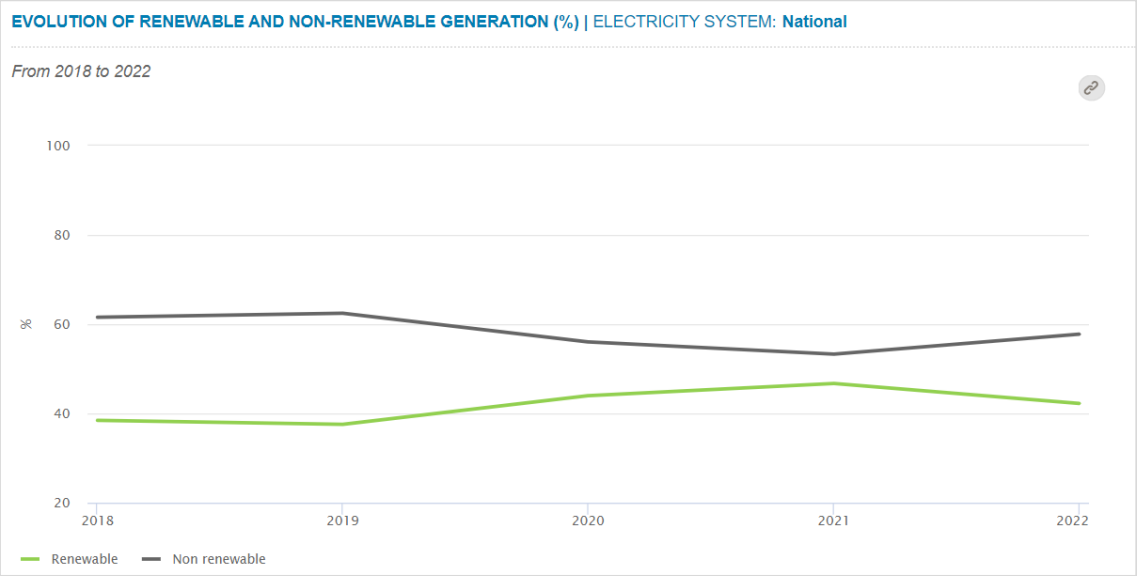

Figure 4. Percentage of annual generation by renewable and non-renewable sources, Spain 2018 - 2022. Source: REE. (2023).

It is also important to note that the fuel cost sensitivity of the average LCOE for a gas generator is considered to be very high when compared to other technologies (for example,

nuclear LCOE depends highly on fixed costs and no so much on fuel and operating costs) (21).

Therefore, a change in natural gas price heavily affects the generation cost of CCGT and other gas power plants. As they bid higher in the market, if they are cleared, the whole market displays a higher price because it is marginal.

In recent months, an unusual increase in natural gas prices has made the market reach record prices in many countries. There are several reasons for this escalation that started in the last months of 2021 (22):

- After Covid 19 lockdowns, in the second semester of 2021 there was a sudden surge of natural gas demand for industries while, at the same time, European governments tried to minimize the use of other fossil fuels due to sustainability commitments.
- Cold waves in China, USA and other regions have also had an impact in the growth of natural gas demand.
- Many facilities involved in the natural gas value chain were set to have maintenance works for a certain period in 2021, as many maintenance works had not been performed during the lockdown in 2020.
- Geopolitical issues, such as Morocco interrupting the natural gas flow coming from Algeria.
- Groningen reservoir stopping operation, increasing the dependence of Europe on imports.

When the market was still recovering from these issues, the invasion of Ukraine by Russia in February 2022 altered it to record levels. Russia is one of the world's largest exporters of oil and natural gas, especially to Europe and many gas routes cross Ukraine (23). Experts explained that as long as the war lasts, "European nations will face higher rates of inflation and a supply chain disruption", advising that "even though it would be costly to Russia, Russia (EU major energy exporter) might respond to EU sanctions by restricting oil, gas and coal exports." (24). As a response to these events and speculations, market prices of natural gas skyrocketed.

The Spanish government, among others, has imposed temporary mitigation measures to limit the price of natural gas to produce electricity ("excepción ibérica" or Iberian exception[6]), but prices are still highly volatile.

In addition to natural gas prices, the other factor that deeply affects the generation cost of energy for CCGT (and therefore, their bids on the market) is the price of CO_2 emissions. In 2005, the European Union set the Emissions Trading System (ETS), which is now on its fourth phase and sets an EU-wide cap on emissions (25). As explained by the European Commission:

"The overall volume of greenhouse gases that can be emitted by power plants, industry factories and aviation sector covered by the EU Emissions Trading System (EU ETS) is limited by a 'cap' on the number of emission allowances. Within the cap, companies

[6] Royal Decree 10/2022, 13th of May 2022.

receive or buy emission allowances, which they can trade as needed. The cap decreases every year, ensuring that total emissions fall." (26).

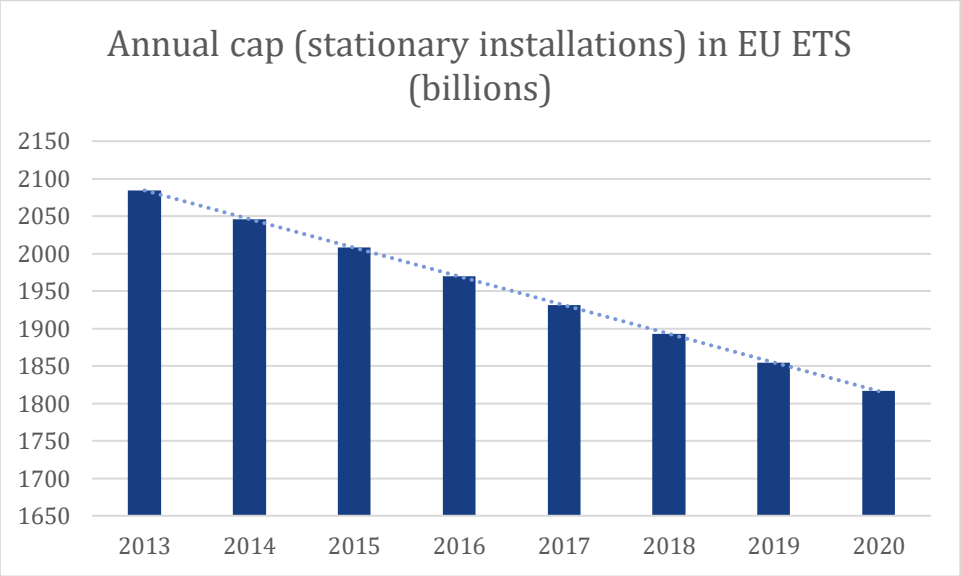

Figure 5. Annual allowances[7] cap for stationary installations in EU ETS. Source: author's own elaboration with information from (27). (2022).

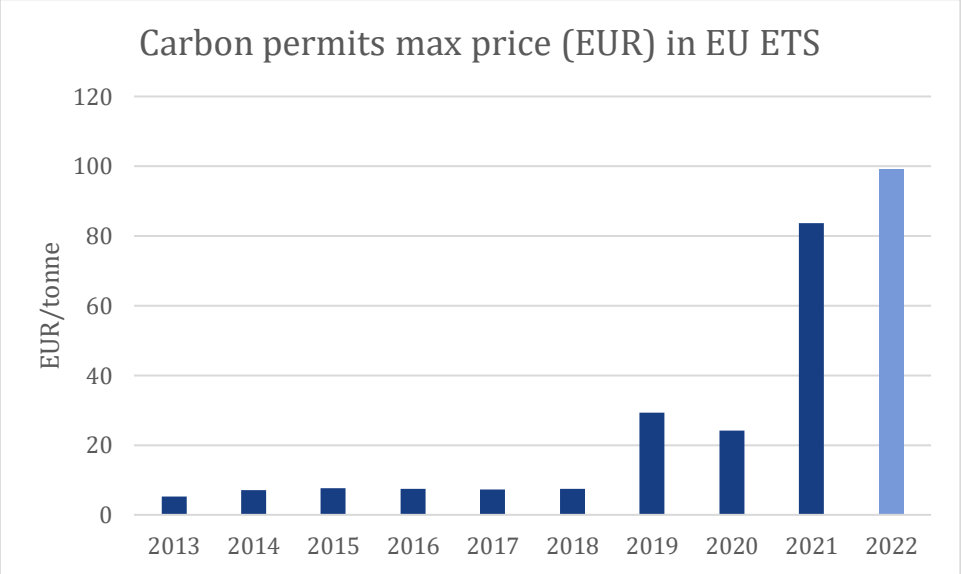

Figure 6. Carbon permits maximum Price (EUR) in EU ETS. Provisional data for 2022. Source: author's own elaboration with information from (28). (2022).

[7] Each allowance gives the holder the right to emit one tonne of CO_2 or the equivalent amount of other powerful greenhouse gases (8).

Therefore, as the supply of CO_2 emissions certificates decreases, it is also expected for its price to rise, affecting CCGTs costs as well.

2.3. Consumer reaction to electricity prices

After explaining the effect of recent events on energy markets and, specifically, how PVPC is influenced by them, the different consumer reactions are explained in the following sub section. Consumer reactions have been divided into two categories: demand (considering consumers can purposefully increase or decrease their demand or switch the consumption pattern) and relationship with retailers (explaining how consumers have interacted with tariffs and other services by electricity retailers).

2.3.1. Demand shifting

Considering electricity demand in all sectors in the European Union is price inelastic in the short run (29), it is safe to assume that the energy consumed by electric appliances does not dramatically vary due to recent events. Some research (30) shows modest savings in electricity via pro-environmental incentives, which are also taken into account in this project.

In addition to a reduction in consumption, some studies analyze the possibility of rearranging the demand according to the different periods in the day, as electricity tariffs often charge different prices according to the time of the day. Generally, the night (valley) is cheaper than the day (alternative periods of flat and peak).

Ofgem, the energy regulator for Great Britain, publishes an extensive report on the potential advantages of this issue. Domestic Side Response (DSR) is defined as "a range of mechanisms designed to reduce peak demands on the electricity system, potentially delivering a number of benefits including reduced cost of electricity supply and improved efficiency of investment in transmission and distribution networks" (31). The article covers a savings estimation for a 3 MW facility, that could save up to 66 k£ in the fixed term and 35-55 k£ in the variable term of the bill, while preventing the system to suffer significant peaks in demand. The report also includes the most common cited barriers when applying DSR, being lack of awareness, no view of wider picture, multi-tenanted buildings and fear of negative impact of service levels among the top tier.

2.3.2. Relationship with retailers

Even though electricity prices have been greatly affected in the last months and changing suppliers or tariffs could be cost effective for many consumers, the behavior of switching from the current alternative to a cheaper or more sustainable option does not always seem to be rationally motivated. Some authors (9) classify the market failure explanations into different categories:

- Information asymmetries and market imperfections, in the cases where one party has more accurate or more detailed information than the other or where the market displays some Pareto's inefficiencies[8], leading to a net loss of economic value.
- Cognitive limitations, loss aversion and biased beliefs. This explanation refers to the cognitive bias that many consumers show in the decision-making process, such as describing the pain of losing more powerful than the joy of gaining or the tendency to interpret information in a manner that confirms one's prior beliefs.
- Unobserved costs, overstated energy savings, ignored product attributes and uncertainty. This explanation includes the misunderstanding of all the factors involved into the decision-making process, poorly calculated energy savings, lack of knowledge about them and inability to accurately include statistical models to account for uncertainty in a reasonable range of scenarios.

This inefficient supplier choice is studied by scholars. The results of a survey carried out in United Kingdom in 2015, show that 56% of respondents claim they have never switched supplier, do not know it is possible or do not know if they have done so (32). In the case of Spain, almost 62% of respondents to the annual CNMC survey (33) declare that they have never switched electricity supplier.

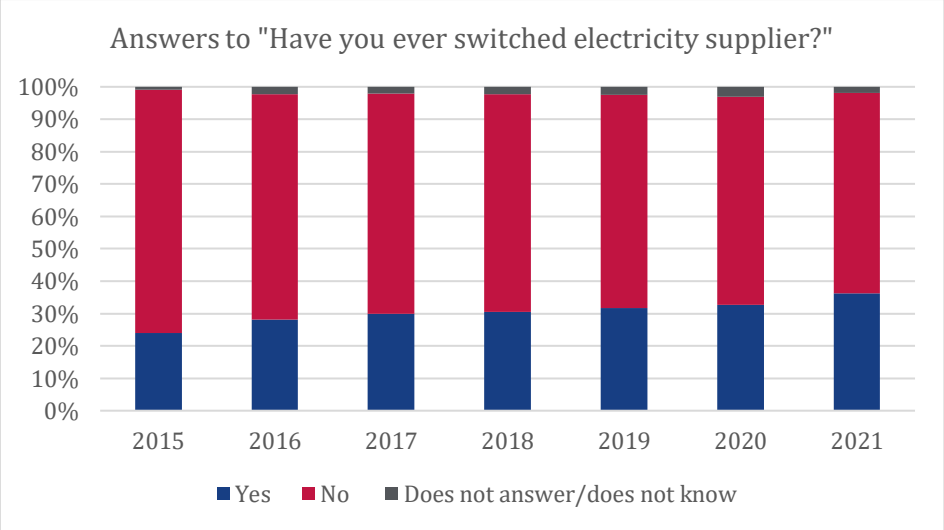

Figure 7. Percentage of respondents of every answer to the question "Have you ever switched electricity supplier?". Source: author's own elaboration with information from (33). (2022).

This figure (although it shows a downward trend) shows how important the default tariff is and points out that there might be some common reasons to that. Later in this project, the weight of some factors such as loss aversion or risk aversion are discussed.

2.4. Drivers of consumer behavior in electricity markets

Behavior strongly affects decisions that are usually considered only dependent on monetary variables. While financials motives are an essential factor in the decision making progress, behavioral patterns are usually left aside and misunderstood. This

[8] A market is Pareto optimal or efficient "if there does not exist an alternative feasible resource allocation which can make some individual better off without making someone else worse off.". (16)

circumstance is described as recklessness by many studies that claim households (as key players in the energy transitions) are usually seen as purely rational individuals that would make decisions based on financial figures, while reality is much more complex (1) (2) (3) (34).

Drivers affecting energy decisions in households might be divided into three categories:

- Demographic parameters. These variables can be objectively measured and are analyzed in multiple studies. Some key parameters here are income or home ownership (both of them are positively correlated with investment in clean energy technologies) (35). Family age-composition structure seems to be positively correlated with the adoption of energy efficient technologies (36).
- Individual perceived cost of selection. In this sense, cost is understood as a sum of time, money and effort. These factors affect the consumer perception towards the cost of: information search, switching from one supplier to the other, time and effort spent in implementing changes to modify efficiency or improve house isolation… Note that this perception is subjective and individual impressions are key: same information presented in different manners can cause a same person to either choose to inform themselves or abandon the subject. Default options (in electricity tariff, in current house isolation and appliances, etc.) become important as the study of any other alternative might be seen as a great personal cost in terms of time, money or effort (37) (38) (39) (40) (41).
- External influences and emotions. Social context, group norms and friends and family relationships affect the way consumers shape ethics, moral and desired public image (35) (42) (4). The Norm Activation Model (NAM) states that environmental friendly behavior is highly influenced by pride (positively) and guilt (negatively) (34), while other frameworks talk about social norms, sense of membership and social identity (41).

A preliminary classification of drivers in the energy decision making progress is established in this section. In the following paragraphs, the analysis moves to Spain and to specific experiments and studies takeing place there.

2.5. Precedents of behavioral energy experiments in Spain

As the experiment will be carried out in Spain, this sub section offers some insights of precedents in past experiments related to behavior in energy matters.

Mir-Artigues et al. (43) studied in 2018 the large impact Spanish regulation had in the deployment of Photovoltaic demand-side generation (prosumers). Authors argued that regulation was "highly unfavorable for the adoption of PV-DSG" and was driving investments away. This is an example of the great effect policy makers can have in energy matters. Even though Spain displays high irradiation levels and seems an outstanding location for these type of investments, regulation and the way it had been perceived by the population prevented investments in the PV-DSG field.

An article published in 2019 gathers data from 22 European countries and studies the behavior of respondents regarding energy efficiency and saving behaviors (44). In the

case of Spain, results show strong and usual stated energy saving behaviors. Thus, Spanish respondents seem prone to adapt certain measures in their energy behavior.

In 2020, a study by Niamir et al. (45) investigated the drivers of household energy behavior in Navarre, a region in the North of Spain. The article focuses on investment in energy efficiency and insulation, switching of energy habits and switching to green electricity sources. The authors conclude that "awareness and personal and social norms are as important as monetary factors. Moreover, education and structural dwelling factors significantly affect households' actions." As stated, there is a mix of factors that hinder the decision-making process to be economically rational.

According to Mercado Sáez (46), the media has an important responsibility regarding energy information. Energy discussions and decisions should be supported by clear and transparent information from the media and the media is not complying with these, therefore leading consumers to certain opinions and choices that are not optimal.

This lack of information or misunderstanding is highlighted by some authors that argue the problem also comes from electricity tariffs, as they are not clear enough for an average consumer (47).

From these examples, several conclusions can be extracted:

- Policy makers, regulation and media have a key role in delineating household electricity behavior.
- Spanish households value other factors other than money when exercising electricity patterns. Specifically, awareness, social norms, education and structural dwelling seem to significantly affect the decision-making process. These drivers can be split into categories as explained in Section 2.4.
- Complexity of electricity tariffs is usually pointed out as another factor affecting decisions, specifically as an obstacle. Default tariff becomes important in circumstances where consumers are afraid of misunderstanding other alternatives or losing time, money or effort in the process.

Once the state of the art is studied and an overview of the Spanish situation is explained, in the next section the project scope is defined.

3. Project scope

In the previous section, a brief summary of the State of the Art is presented. After an introduction to Spanish tariffs and, specifically, to PVPC, the section also considers how recent events impact the latter through the marginal market mechanism. Following the line of thought, consumer reaction is disaggregated into different procedures. The following step is then a deep dive into the reasons why consumer react to energy decisions or how they conform their behavioral energy patterns. Lastly, some examples of behavioral energy experiments in Spain are added.

3.1. Motivation

The motivation of this project can be derived from Section, 2.5, and its final points:

- Spanish households consider several factors (not only economic ones) when making energy decisions such as promoting renewable energy, choosing an electricity retailer or implementing efficiency measures.
- Although not many previous experiments can be found, the complexity of energy matters seems to be a common perceived obstacle. Therefore, even though a consumer might think they are not applying the optimal decision, they do not consider spending resources to study further alternatives.
- Behavioral policy making is demonstrated to be an efficient tool in promoting or hindering certain conducts.

Therefore, the motivation of this project can be summarized in the following statement:

Understanding drivers behind decision making process in electricity-related topics in Spanish households

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As the motivation of the project might seem too ambitious and could be extended to many subjects, the specific set of goals to achieve in this project is defined in the next sub section.

3.2. Objectives

In order to narrow down the stated motivation into distinct and detailed objectives, the following goals are presented:

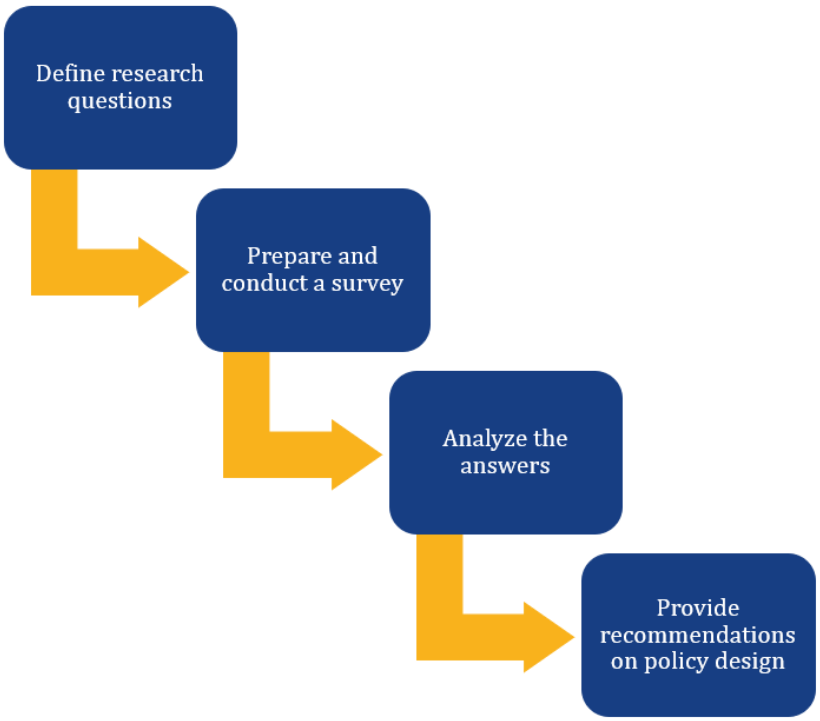

Figure 8. Objectives of the project. Source: author's own preparation. (2022).

1. Define research questions. Define the potential patterns and drivers to be studied.
2. Prepare and conduct a survey. Obtain data from, at least, a sample of a certain number of people, regarding their beliefs towards sustainable electricity sources, electricity tariffs and actual circumstances (what they are currently doing and how they perceive current electricity choices). The exact number of people needed is calculated in Section 7.2 taking into consideration level of statistical power, precision needed and type of test.
3. Analyze the answers. Analyze the information to capture trends, correlations and detect inconsistencies. Summarize significant results and study the possible internal and external validation.
4. Provide recommendations on policy design. Departing from the main results, elaborate a list of potential suggestions to policy makers in terms of behavioral decision making in energy-related topics.

Since the development of the project is subject to the quality of the experiment or pilot, the next sub section (3.3) focuses on its preparation.

3.3. Methodology

In order to obtain input information for the analysis of the current situation in Spain, an experiment (a survey) is carried out. Several critical components must be studied for designing and studying a successful pilot (48):

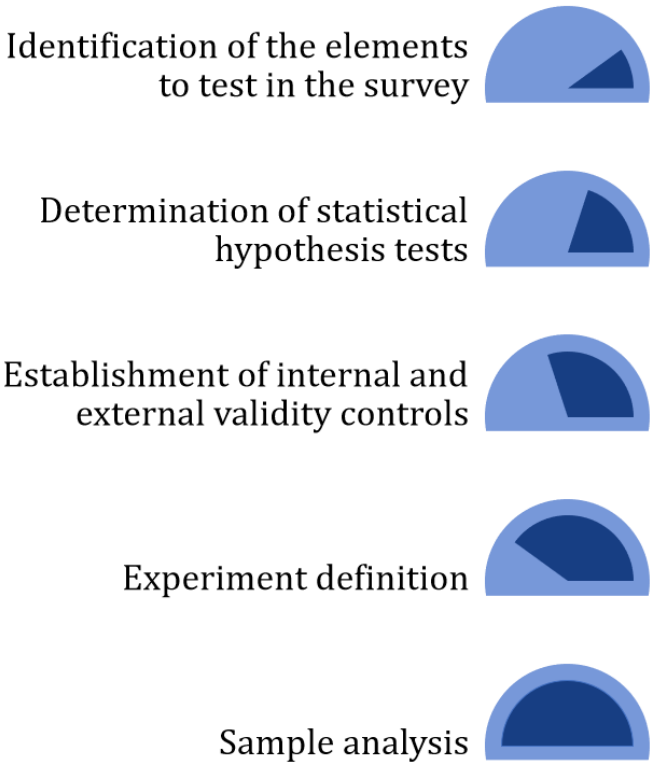

Figure 9. Key parameters to be determined before a pilot can be designed. Source: adaptation from (48). (2022).

The definition of these five steps is the following:

1. Identification of the elements to test in the survey. Determine which specific perceptions or behaviors by respondents are the outcomes of interest of the survey, what information the questions should be retrieving.
2. Determination of statistical hypothesis tests. Establishing which tests will be applied to the gathered sample and defining a threshold to accept or reject null hypotheses.
3. Establishment of internal and external validity controls. Understanding how external factors might affect the outcome of responses in the survey and how applicable are conclusions to the population-wide extent, discerning if extrapolation to Spanish population is feasible or not.
4. Experiment definition. Estimating how many respondents are needed to achieve the levels of power and precision in statistical tests, targeting respondents, designing the questions for the survey and launching and sending the experiment.
5. Sample analysis. Includes preliminary data treatment and control to the sample and analysis of results via statistical tests. Once the results are analyzed, extract conclusions.

Once the steps are defined, the application to the survey is explained in the following sections.

4. Identification of the elements to test in the survey

The topics to be studied in this project are detailed in the following points. For every one of them, a brief explanation on the reasons to include them is also added.

- **Ecologically sustainable framing**. Framing is the process of explaining the same outcome of a risky decision from different perspectives, as gains or losses relative to the status quo (49). The survey randomly assigns individuals to either a positive sustainability frame or a negative sustainability frame. Positive framing exposes an optimistic situation (high share of renewables in the system and expected growth) and negative framing exhibits pessimistic circumstances (a handful of companies emitting the majority of CO_2 emissions, difficulty to impact the bigger picture as a consumer). This type of questions is tested in previous research in other European countries and studies show that positive framing has indeed a positive correlation with the Stated Willingness To Pay (SWTP) for "green energy" (7) (8). It is also stated that the responses to framing are higher when the frame emphasizes the biosphere consequences (hazard to the natural environment), rather than egoistic consequences (e.g. threat to one's health) (8). After the respondents are exposed to the framing, they are asked about their willingness to pay for an electricity retailer that offers renewable energy. The aim of these questions is to understand if the different sustainability framings affect the willingness to pay for renewable sources of energy of the respondents.
- **Loss aversion**. While the adoption of some energy decisions choices might be financial and environmentally wise, it is observed by previous studies that some choices are not being adopted to the degree that might be justified or reasonable (14). One of the factors that could explain this phenomenon is the loss aversion, defined as a utility function which is steeper for losses than for gains (5). Therefore, probability weights differently or in a non-consistent manner when talking about gains or losses.

  Some questions the experiment are aimed to target this loss aversion, to understand how it interacts with other psychological and demographic factors.

  A key point to study in this project is the influence of PVPC on loss aversion, so the analysis of the sample also studies the interaction of PVPC holders and responses to loss aversion questions.
- **Risk aversion**. Risk aversion might be defined as the irrational fear (or fanciness) of uncertainty. Pratt (6) and Arrow (50) elaborate a theoretical function that aims to characterize this parameter taking the utility function as a starting point and that is widely used to study investor behavior in the financial sector. The final result would be a function dependent on wealth.

  In the electricity sector, it is proved by preceding studies that risk aversion takes a leading role in corporate firms when it comes to electricity retail contracting or procurement (51) (52) or investment in generation capacity (53).

On the other hand, empirical results (taken years later than the formulation of the Arrow-Pratt risk aversion measure) (54) claim that risk aversion among households can affect different consumption domains: occupational choice, portfolio, insurance demand, investment in education, migration, consumer preferences… Besides income or wealth (already pointed out by Arrow-Pratt), some results also reflect a positive correlation between risk aversion and age (12) and influences by national culture (13). In this project, one of the objectives is to determine how demographic information correlates with risk aversion.

- **Willingness to change habits**. Finally, the pilot should not only try to explain the different decisions regarding energy in households, but also which factors prevent change and which factors motivate it. Some of the obstacles already been pointed out in literature (15) (16) (17) are: lack of information, administrative problems, non user-friendly technologies, complexity and lack of awareness.

5. Determination of statistical hypothesis tests

In the previous section, the elements to evaluate in the survey are defined (sustainable framing, loss aversion, risk aversion and willingness to change habits). In this section, the statistical tests to apply to every element are specified.

First, a descriptive analysis of the responses gathered in the survey is exposed. This description is followed by specific statistical tests applied to the variables depending on their characteristics (numerical vs categorical variables, binominal vs polynomial variables, etc). The tests to apply to every element are defined in the following subsections.

5.1. Sustainable framing statistical tests

Respondents are randomly assigned to either a positive framing that exposes an optimistic situation (high share of renewables in the system and expected growth) or a negative framing that exhibits pessimistic circumstances (a handful of companies emitting the majority of CO_2 emissions, difficulty to impact the bigger picture as a consumer). After reading the framing, respondents are asked about their willingness to pay for an electricity tariff that assures the source is completely renewable.

5.1.1. t-test

To understand if there are significant differences in the willingness to pay of the groups depending on the received framing, a t-test is applied. The null hypothesis is "There is no difference in the willingness to pay means of those respondents that receive positive framing and those that receive negative framing", expressed as:

$$H_o: \mu_{positive\ framing} = \mu_{negative\ framing}$$

and the alternative hypothesis:

$$H_1: \mu_{positive\ framing} \neq \mu_{negative\ framing}$$

5.1.2. Correlation

In addition to the t-test, correlation with other variables is studied as well. Correlation for every variables interacting with the sustainable framing questions is measured with the Spearman's ρ.

5.1.3. ANOVA

Lastly, a One-Way ANOVA test is performed to study if respondents can be grouped into significantly different groups according to any of the other variables. The null hypothesis is "When responses of willingness to pay after sustainable framing are grouped by variable i, no difference in the mean of the resulting groups is observed", expressed as (for every *i* in the set of variables that can take up to *k* values):

$$H_o: \mu_{group1} = \mu_{group2} = \cdots = \mu_k \quad for\ k\ independent\ comparison\ groups$$

and the alternative hypothesis:

$$H_1: the\ means\ of\ the\ groups\ are\ not\ equal$$

To evaluate the significance of the results, **p-values are studied considering conventional thresholds applied in the literature ($p < 0.05$, $p < 0.01$ and $p < 0.001$)**.

5.2. Loss aversion statistical tests

Loss aversion is a part of the survey that tries to understand if consumers have previously thought about changing electricity retailer, if they think they could be paying a cheaper bill and the potential obstacles that might appear when trying to change the tariff or retailer for the household consumption.

5.2.1. Principal Component Analysis

The survey includes a question about the obstacles when changing electricity retailer that is studied in the loss aversion part. The first step is to determine, by a Principal Component Analysis, if these obstacles could be summarized in a lower number of variables.

5.2.2. Correlation

Correlation of loss aversion questions with other variables in the survey is also studied. Correlation for every variable interacting with the loss aversion questions is measured with the Spearman's ρ.

5.2.3. ANOVA

A One-Way ANOVA test is performed to study if loss aversion respondents can be grouped into significantly different groups according to any of the other variables.

The null hypothesis is "When responses of loss aversion are grouped by variable i, no difference in the mean of the resulting groups is observed", expressed as (for every *i* in the set of variables that can take up to *k* values):

$$H_o: \mu_{group1} = \mu_{group2} = \cdots = \mu_k \quad for\ k\ independent\ comparison\ groups$$

and the alternative hypothesis:

$$H_1: the\ means\ of\ the\ groups\ are\ not\ equal$$

5.2.4. χ2 hypothesis test

Lastly, χ^2 hypothesis test is applied to understand if consumer that enjoy PVPC have significant different responses to those enjoying free market tariffs. The null hypothesis

is "There is no difference in the loss aversion in the respondents that have PVPV vs the ones that have a free market tariff", expressed as:

$$H_o: loss\ aversion\ is\ independent\ of\ type\ of\ current\ tariff$$

and the alternative hypothesis:

$$H_1: loss\ aversion\ depends\ on\ the\ type\ of\ current\ tariff$$

To evaluate the significance of the results, **p-values are studied considering conventional thresholds applied in the literature ($p < 0.05$, $p < 0.01$ and $p < 0.001$)**.

5.3. Risk aversion statistical tests

The risk aversion section in the survey is aimed to verify the comprehension of respondents regarding fixed and variable tariffs and the preferences when choosing an electricity tariff. The variable tariff final payment depends on a probabilistic function.

5.3.1. Correlation

Correlation of risk aversion questions with other variables in the survey is also studied. Correlation for every variables interacting with the risk aversion questions is measured with the Spearman's ρ.

5.3.2. ANOVA

A One-Way ANOVA test is performed to study if risk aversion respondents can be grouped into significantly different groups according to any of the other variables.

The null hypothesis is "When responses of risk aversion are grouped by variable i, no difference in the mean of the resulting groups is observed", expressed as (for every *i* in the set of variables that can take up to *k* values):

$$H_o: \mu_{group1} = \mu_{group2} = \cdots = \mu_k \quad for\ k\ independent\ comparison\ groups$$

and the alternative hypothesis:

$$H_1: the\ means\ of\ the\ groups\ are\ not\ equal$$

5.4. Willingness to change habits statistical tests

The WTCH section in the survey is aimed to verify the comprehension of respondents regarding fixed and variable tariffs and the preferences when choosing an electricity tariff if the final bill depends directly on their energy behavior. The variable tariff final payment might depend on the hours of consumptions and other swift behaviors.

5.4.1. Correlation

Correlation of willingness to change habits questions with other variables in the survey is also studied. Correlation for every variables interacting with the willingness to change habits questions is measured with the Spearman's ρ.

A One-Way ANOVA test is performed to study if WTCH respondents can be grouped into significantly different groups according to any of the other variables.

The null hypothesis is "When responses of WTCH are grouped by variable i, no difference in the mean of the resulting groups is observed", expressed as (for every *i* in the set of variables that can take up to *k* values):

$$H_o: \mu_{group1} = \mu_{group2} = \cdots = \mu_k \quad for\ k\ independent\ comparison\ groups$$

and the alternative hypothesis:

$$H_1: the\ means\ of\ the\ groups\ are\ not\ equal$$

5.4.2. McNemar test

As both risk aversion and WTCH sections present fixed vs variable electricity tariffs, a McNemar test is applied to these two elements to verify if there is a change in proportions of people choosing one type of tariff (fixed or variable) and then choosing the other one depending on what is the driver of the final bill (a probabilistic function in the case of risk aversion and the consumer behavior in the case of WTCH). The null hypothesis is "Proportions of respondents preferring a variable tariff that depends on a probabilistic function is equal to proportion of respondents preferring a variable tariff that depends on their behavior", expressed as:

$$H_o: p_{prefers\_variable\_prob} = \mu_{prefers\_variable\_beh}$$

and the alternative hypothesis:

$$H_1: p_{prefers\_variable\_prob} \neq \mu_{prefers\_variable\_beh}$$

6. Establishment of internal and external validity controls

6.1. Internal validity

The different possible external effects affecting the survey responses are taken into consideration. Following the classification of potential factors interfering with internal validity in (55), the items below are especially considered for this project:

- Experimental mortality. To avoid subject non-adherence or incomplete responses, the experiment take less than 10 minutes to complete in average. It is found that an experiment taking more than longer times significantly increase the drop-out rate (56).
- Blinding. Individuals are not told what the exact reason of the experiment is or the treatment they are receiving, in order to avoid bias. Therefore, they do not know the elements that are tested in the experiment, as explained in 4 (Loss aversion, Risk aversion, Ecologically Sustainable framing and Willingness to change habits).
- Adherence to the protocol. In order to accurately perform comparisons, once the experiment is designed and some respondents already answer, the questions and hypotheses to test are not modified.
- Statistical controls to establish randomization is correctly performed, manipulation check is included, no priming effect takes place, etc.

6.2. External validity

Enabling the results of the experiment to be extrapolated to other group of users who are not part of it implies that the pilot enjoys external validity. One major threat to this is selection bias, which is "the effect of some selection factor of intact groups interacting with the experimental treatment that would not be the case if the groups were randomly selected" (57).

To avoid performing the experiment on people with common profiles that would similarly answer to the questions, some collaborations are explored to spread the experiment across people with different backgrounds and demographic information, as well as with different knowledge about the electricity sector.

7. Experiment definition

7.1. Segmenting consumers and targeting respondents

While electricity is a basic need and every household is subscribed to a certain retailer, not all consumers understand how to distinguish the different offers. According to CNMC, only 1 out of 4 households knows the difference between PVPC and free market (18).

In addition to this, psychological drivers and exogenous stimulus might influence the decision of selecting an electricity retailer. Thus, the respondents also answer questions about their demographic features and current electricity retailer option.

7.2. Calculating sample size

Once the different target respondents are identified, the minimum sample size to consider the experiment valid is calculated. The tool to be used for this calculation is G*Power (58).

The inputs for the program are be detailed below:

- Type of test: Protocol of power analyses, Means of two independent groups. A priori: Compute required sample size – given α, power and effect size. Two groups are considered to separate positive and negative framing.
- Tail(s): Two. Selecting two instead of just one tail will allow to determine the possibility of an effect in two directions (positive and negative).
- Effect size d: 0.5. Conventionally, an effect size of 0.5 is considered medium.
- α err prob: 0.05. Chosen by convention as well.
- Power (1 – β err prob): 0.8. Used to detect the effects of sample size, chosen by convention.
- Allocation N2/N1: 1. The reason for this is to assume a same number of participants in every treatment group.

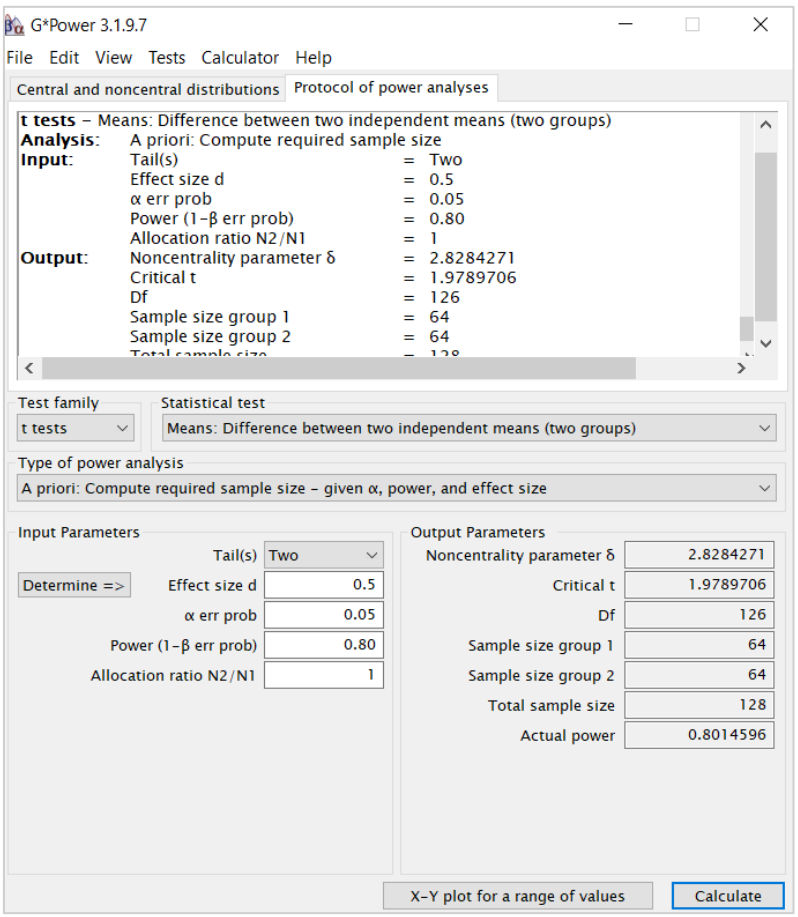

*Figure 10. G*Power interface showing inputs and outputs for sample size calculation. Source: G*Power (58). (2022).*

The outcome from G*Power states that the total sample size should be **128 people**, considering **64 people in each group** N1 and N2. This is the minimum sample size targeted to ensure power reaches 80%.

7.3. Exploring collaborations

A + Familias is a Non-Governmental Organization based in Madrid that contacts vulnerable families in order to provide basic needs in difficult situations. Although traditionally focused fighting hunger, they have recently started to prepare workshops to assess families regarding energy suppliers and best practices to optimize consumption. A collaboration with them is studied and carried out in order to contact vulnerable consumers.

In addition to this, a possible collaboration with the university in order to reach respondents within the academic community is explored.

7.4. Designing the questions

In the design process, several concepts have to be taken into consideration:

- The targeted elements to test (loss aversion, risk aversion, ecologically sustainable framing and willingness to change habits), as explained in 3.3.
- Possible variables that can differentiate respondent segments.
- Questions that are later used to perform statistical tests and controls.

The final questionnaire can be found in "Annex II. Spanish questionnaire" and "Annex III. English questionnaire".

The diagram below shows the flows and main concepts included in the questionnaire. In the following sub section, reasoning and explanation for the questions will be discussed.

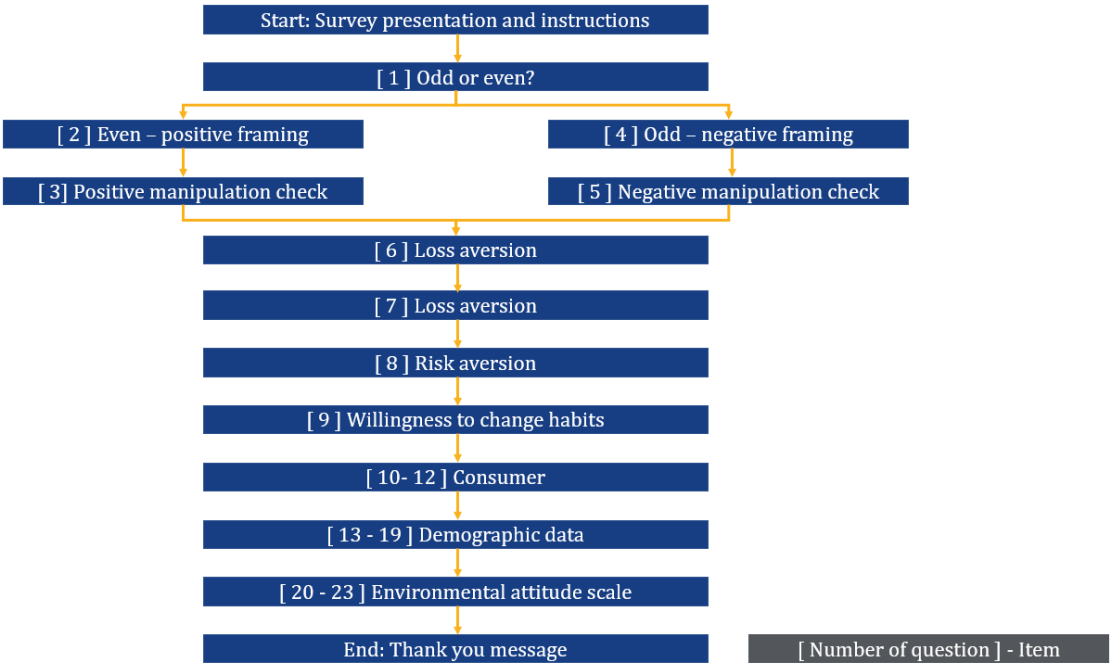

Figure 11. Survey diagram. Source: author's own preparation. (2022).

7.4.1. Randomization and manipulation checks: framing

After an initial presentation where respondents are asked to provide informed consent and ensured the anonymity of data, respondents are divided in two different groups. To ensure **random assignation** to groups, the question to allocate respondents is "Is your birthday date odd or even?" (see "Annex II. Spanish questionnaire" and "Annex III. English questionnaire", Question 1).

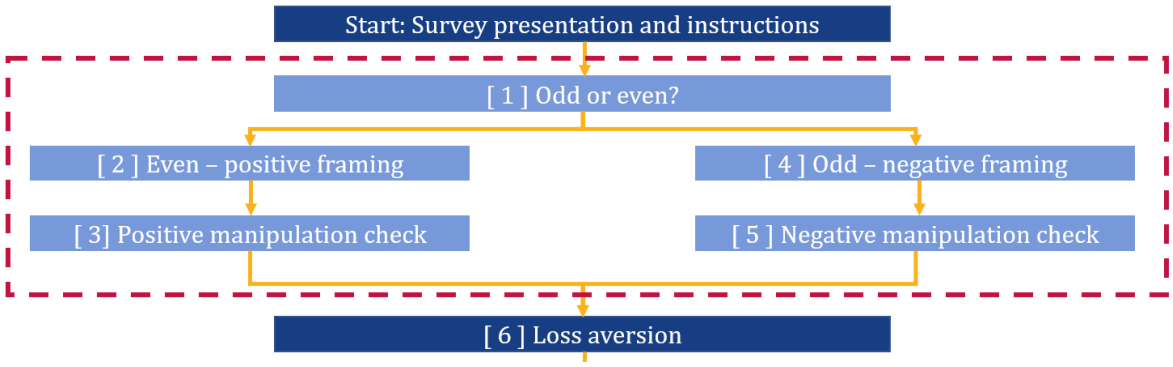

Figure 12. Random framing and manipulation checks. Source: author's own preparation. (2022).

"Even" response leads to a **positive framing** (see "Annex II. Spanish questionnaire" and "Annex III. English questionnaire", Question 2), while "Odd" leads to a **negative framing** (see "Annex II. Spanish questionnaire" and "Annex III. English questionnaire", Question 4).

To ensure that the respondents understand the framing context, a **manipulation check** is included (see "Annex II. Spanish questionnaire" and "Annex III. English questionnaire", Questions 3 and 5). A manipulation check is used "to ensure participants perceive, comprehend, and/or react as expected to the portion of the manipulation of interest contained within the independent variable" (59). Both groups receive similar manipulation checks so the content does not further affect the rest of the questionnaire.

Options also include "I do not understand the question" to evaluate what share of the sample do not comprehend the given information or answers.

After this random framing exposure, all respondents are led to a series of common questions.

7.4.2. Preferences: loss aversion, risk aversion and willingness to change habits

In the section called "Preferences", respondents face loss aversion, risk aversion and willingness to change habits options.

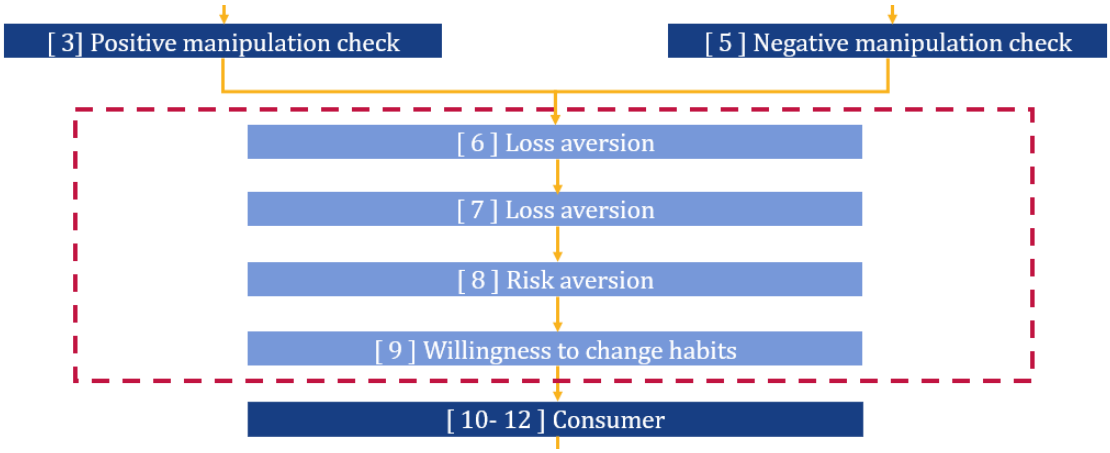

Figure 13. Loss aversion, risk aversion and willingness to change habits. Source: author's own preparation. (2022).

Loss aversion is measured in two questions (see "Annex II. Spanish questionnaire" and "Annex III. English questionnaire", Questions 6 and 7). Participants are asked about their reflections on changing electricity retailers and if they think they could be paying less for their electricity bill. These two questions aim to test if the sample thinks they could be paying less but still do not think about leaving their current option.

Next question's topic is **risk aversion** (see "Annex II. Spanish questionnaire" and "Annex III. English questionnaire", Question 8). Participants receive information about two electricity companies. One of them offers a fixed tariff, while the other one offers a variable tariff. For the last one, participants are given some percentages of how cheap and how expensive their bill could be.

> Company 1. It offers a fixed 100 €/month tariff. Your bill will always be that amount, regardless of your consumption or the different consumption hours.
>
> Company 2. It offers a variable tariff. You know there is 87.5% probability of ending up paying 80 €/month. There is also 12.5% probability of ending up paying 160 €/month. You will not know your final debt until you receive the bill.

If consumers were completely rational, the second option would seem more attractive, as probabilistically it means a cheaper option. Note that:

$$Company\ 1 = 100\ €/month$$

$$Company\ 2 = 87.5\% \cdot 80 + 12.5\% \cdot 160 = 90\ €/month$$

Lastly, to close this section, **willingness to change habits** is tested. Respondents are offered a fixed tariff (Company 1) and a tariff that depends on the time periods the person consumes.

> Company 1. It offers a fixed 100 €/month tariff. Your bill will always be that amount, regardless of your consumption or the different consumption hours.
>
> Company 2. It offers a variable tariff. You know if you change your habits and consume electricity at specific time periods, your bill will be about 50 €/month. However, if you consume in the most expensive hours, your bill will go up to 150 €/month.

Options also include "I do not understand the question" to evaluate what share of the sample did not comprehend the given information or answers.

7.4.3. Consumer

The topic of the following section is the current situation the consumer faces (type of electricity tariff and social bonus or "bono social" application) and the obstacles that the person might have encountered in past experiences trying to change tariff or company.

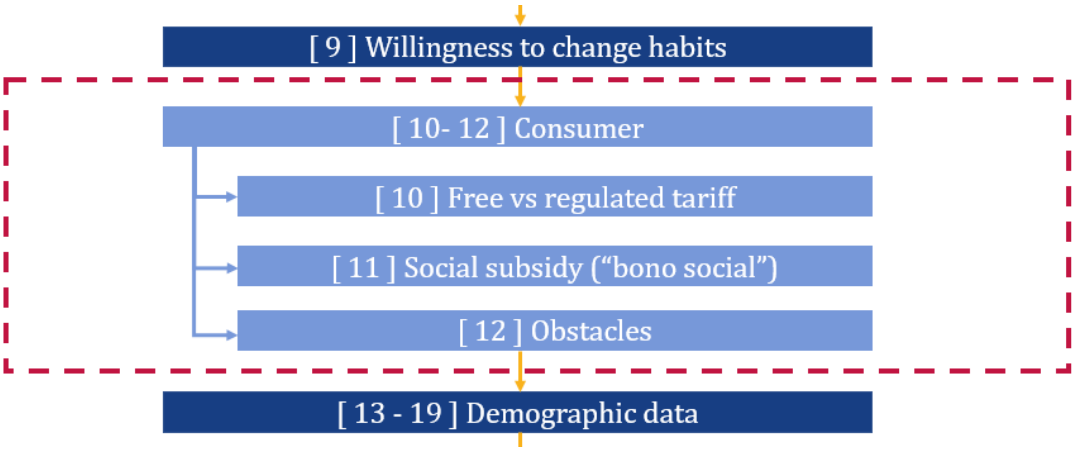

Figure 14. Consumer. Source: author's own preparation. (2022).

These questions do not aim to test any specific psychological factor, but will be used to measure consumer knowledge and if they seem to be a determinant driver for other questions (e.g., what if consumers that do not know about their electricity bill are more risk averse?).

7.4.4. Demographics

As explained in 3.3, external validation is only possible if the survey gathers responses from candidates from different backgrounds and exposed to distinct external contexts. Therefore, it is necessary to ask several questions regarding gender, age and other demographic variables.

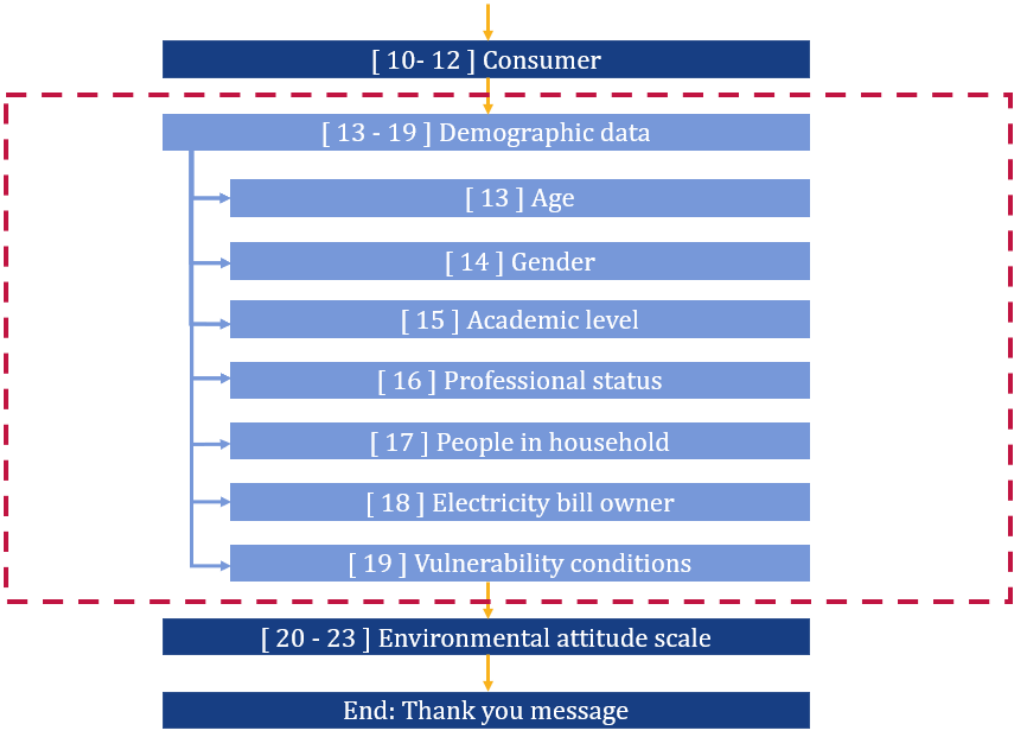

Figure 15. Demographic data. Source: author's own elaboration. (2022).

Even though traditionally demographic data collection is placed at the beginning of surveys, research has shown that this might cause a "stereotype threat" (60). This phenomenon is a bias that arises with the fear of "confirming, as self-characteristic, a negative stereotype about one's group" (61). Therefore, in the present survey the demographic data collection takes place after asking the test questions about framing, loss aversion, risk aversion and willingness to change habits.

7.4.5. Environmental attitude scale

Wide research (62) (63) (64) shows that belief and attitude are essential to predict behavior: "… the best predictor of a person's behavior is his (*sic*) intention to perform the behavior" (62).

As sustainability framing is included as one of the concepts to test in the inquiry, an environmental concern scale is added as well. This environmental attitude scale serves the purpose of determining possible correlations regarding attitude (scale) and behavior (what they would choose in the sustainable framing questions). In other words, it is a test to see if respondents that would pay more for a retailer with Guarantees of Origins were already prone to those answers as their general attitude towards sustainability issues is strong.

The chosen scale for this project is Lounsbury and Tornatzky's (65). However, not all questions from the original scale are added to the current questionnaire, as it would make it too prolonged and might motivate experimental mortality. Instead, only the first four questions are introduced in the survey. The selection of these four questions is based on the high robustness, reliability and validity they show ($\alpha = 0.83$, $\omega = 0.83$), according to a literature review of environmental attitude scales (66).

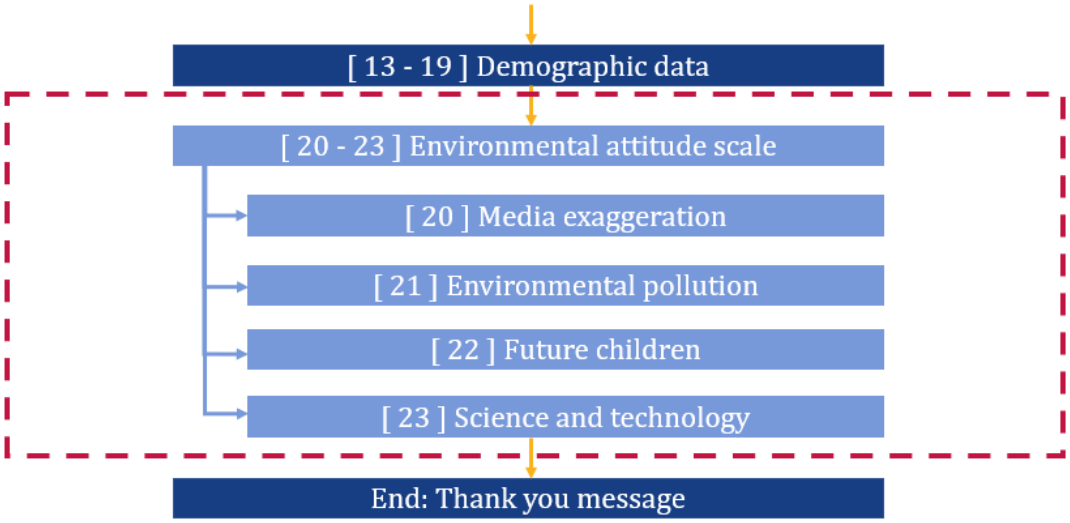

Figure 16. Environmental attitude scale. Source: author's own preparation. (2022).

Respondents are able to answer with a scale, being 1 = "Strongly disagree" and 5 = "Strongly agree". It is important to note that two out of the four questions in this section (see "Annex II. Spanish questionnaire" and "Annex III. English questionnaire", Questions 21 and 22) receive a higher answer if person shows sustainability concern. The other two (see "Annex II. Spanish questionnaire" and "Annex III. English questionnaire", Questions 20 and 23) receive a lower answer if person does not show environmental concern. Therefore, two questions are reversely coded when analyzing responses.

No. of Question	*Questions*	*Need to reverse answer?*
20	The news media have exaggerated the ecological problem	Yes
21	If humankind is going to survive at all, environmental pollution must be stopped	No
22	I am worried about future children's chance of living in a clean environment	No
23	We shouldn't worry about environmental problems because science and technology will solve them before very long	Yes

Table 2. Environmental attitude scale included in questionnaire. Source: (65), (66).

7.5. Launching and sending the experiment

Once all the questions of the questionnaire have been defined, the next step is to choose a platform to launch the survey and spread it across different channels.

7.5.1. Software

Google Forms is the platform used to house the survey. Some reasons for this selection are:

- This tool can be used for free, only requirement is to have a gmail account.
- This platform is easy to utilize both as a designer and as a respondent. Interface is user friendly.
- It includes options to make some questions compulsory, separate questions into different sections and easily launch the survey via link.

Figure 17. Google Form's icon. Source: Google. (2022).

7.5.2. Channels

In Section 7.2, a minimum of 128 people (considering 64 people in each framing group N1 and N2) is calculated to ensure experimental accuracy and validity. In order to reach such amount of people, several channels are used:

- Social media such as WhatsApp, Instagram… these platforms target people close to the survey senders, such as students from Universidad Pontificia Comillas, researchers from Instituto de Investigación Tecnológica (IIT) or relatives.
- As specified in Section 7.3, the survey is also sent to a Non-Governmental Organization, "A + Familias", to reach potentially vulnerable consumers.
- Online forums. Specifically, the survey is posted on "Decide Madrid"[9], an online portal for citizens from the Madrid region to discuss proposals. The range of population for the survey is set to all quarters in the region.

[9] https://decide.madrid.es/

Figure 18. Decide Madrid forum interface. Source: screenshot from Decide Madrid. (2022).

8. Sample analysis

The sample gathers 246 responses, considering both Spanish and English data points. This figure is higher than the required sample size considered in Section 7.2, so it is expected to achieve the defined levels of accuracy and validity. The analysis is performed with Jamovi software (67) (68) (69).

8.1. Preliminary data treatment and control

In the following paragraphs, a series of preliminary checks are performed over the sample. These controls ensure the final sample only includes candidates who have correctly understood the framing, that the randomization between groups is visible and that the environmental concern scale added at the end of the survey shows the expected reliability pointed out by the literature.

8.1.1. Coding questions and answers

In order to ease variable manipulation, a shortened name is given to each one of the questions (e.g., "Is your birthday date odd or even?" was renamed as "day", for full details see "Annex IV. Statistical tests").

In the same line, responses are also coded (e.g., "Free market" was coded as "0", for full details see "Annex IV. Statistical tests").

Note that Questions 20 and 23 are reversely coded (see explanation in Section 7.4.5).

8.1.2. Manipulation check

As explained in Section 7.4, a manipulation check is included in the survey, in the sustainable framing section.

Respondent	*Total*	*Number of incorrect responses*	*% of Incorrect responses*
Odd	131	4	3.1%
Even	115	8	7.0%

Table 3. Manipulation check, incorrect responses. Source: own survey. (2022).

Therefore, these responses are left out for the analysis, as it is considered the framing is not properly understood by these candidates. **The valid sample amounts to 234 participants**.

8.1.3. Randomization test

In order to separate candidates into two different groups, their date of birth is asked. Thus, a randomization test is needed to determine if these groups show significant differences in demographic characteristics, i.e. to determine if the randomization has been successful, so that both groups are similar in gender, age, level of academic studies, number of people in the household, professional status and environmental concern. For further details, see "Annex IV. Statistical tests".

Numerical answers are assessed with a t-Test and categorical answers are evaluated with a χ^2 hypothesis test.

It is determined that **the groups are not significantly different** for $\alpha = 0.05$ in terms of gender, age, level of academic studies, number of people in the household, professional status and environmental attitude scale. Thus, it is assumed that the **randomization is correctly performed**.

8.1.4. Priming effect

As the survey presents the questions to test the other elements after the sustainable framing part, a statistical test is performed to understand if there are significant differences in the responses of both framed groups (see "Annex IV. Statistical tests" for further details).

In other words, this test is performed to verify if the sustainable framing could also affect the responses for loss aversion, risk aversion and willingness to change habits.

The results indicate that **there is no priming effect**: loss aversion (p-value = 0.960 for Q6 and p-value = 0.137 for Q7), risk aversion (p-value = 0.470) and willingness to change habits (p-value = 0.885) sections remain unaffected by the initial framing and separation into two groups.

8.1.5. Measure of reliability of environmental attitude scale

As explained in 7.4.5, the Lounsbury and Tornatzky's scale is included at the end of the survey. A reliability analysis is performed for the four related questions. The Cronbach's α, exceeding the 0.7 threshold, proves that the **environmental attitude scale shows adequate reliability**.

Scale reliability	Cronbach's α
scale	**0.758**
Item reliability statistics if item dropped	Cronbach's α
scale_media	0.707
scale_pollution	0.692
scale_children	0.706
scale_science	0.702

Table 4. Cronbach's α for Lounsbury and Tornatzky's environmental attitude scale. Source: own survey and (65). (2022).

8.1.6. Measure of Common Method Bias

Common Method Bias ("variance that is attributable to the measurement method rather than to the constructs the measures represent" (70)) is inspected as well.

A Principal Component Analysis is performed over all the variables. As the resulting components explain a low percentage of variance (Component 1 explains 11.66%, Component 2 explains 8.49%, Component 3 explains 7.10%...), it is determined that **Common Method Bias is not a problem in the sample** (see "Annex IV. Statistical tests" for further details on the PCA).

8.2. Results

In this section, responses for the four topics are displayed.

8.2.1. Sustainable framing and Willingness To Pay

After splitting the respondents into two groups, each group receives a frame regarding renewable generation and CO_2 emissions. After that, candidates are asked about their willingness to pay for a retailer than offers 100% of energy with Guarantees of Origin ("Company 1") vs a retailer that does not disclose the source of the energy ("Company 2").

The alternatives to the questions are:

- No
- Yes, I would pay up to an additional 3%
- Yes, I would pay up to an additional 6%
- Yes, I would pay up to an additional 9%
- Yes, I would pay more than an additional 9%
- I do not understand the question

Responses for Q2 and Q4

For both framed groups, the distribution of responses is shown in the chart below:

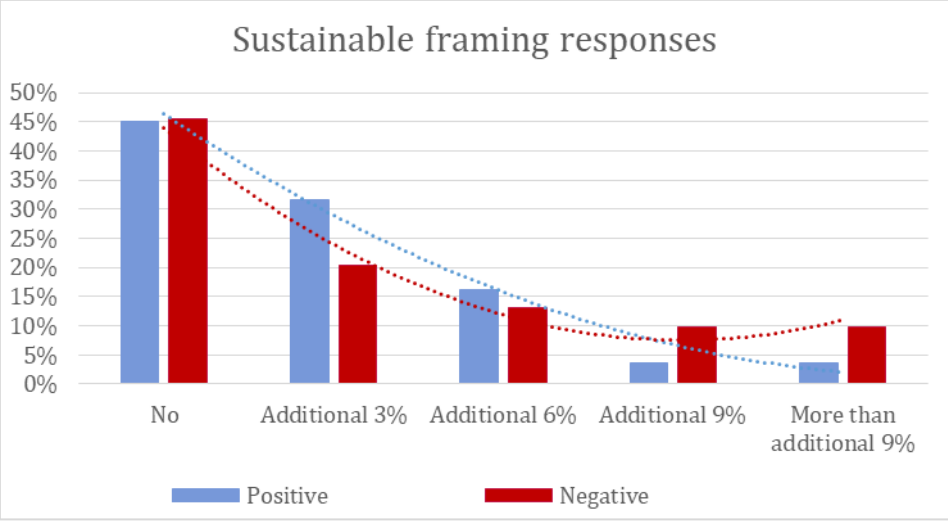

Figure 19. Sustainable framing: distribution of responses and polynomic function approximating distribution for "Would you pay more to choose Company 1?". "I do not know" responses excluded. Source: survey and author's own preparation. (2022).

In order to verify the effect of the sustainable framing, a t-Student is performed. The results of the t-Student indicate (for $\alpha = 0.05$) that **there is indeed some influence by the framing on the groups** ($p = 0.044$, for further details regarding the statistical test, go to "Annex IV. Statistical tests").

	Statistic	*df*	*p*

WTP	Student's t	-2.02	232	0.044

Note. H_a μ *positive framing* $\neq$ μ *negative framing*

Table 5. Independent samples t-test. Source: own survey, Jamovi. (2022).

As Figure 19 displays, if there were indeed an influence by the framing, it would have an unexpected direction:

- Those who receive the **negative treatment** ("…there are 100 companies in the world that are responsible for 71% of the carbon dioxide emissions worldwide since 1988. This information leads to thinking that consumer decisions do not affect global outlook.") show higher numbers in the responses that indicate paying an **additional 9% price in their bill or even more** than 9%.
- On the other side, those who receive the **positive treatment** ("One of the main tools to decrease carbon dioxide emissions is renewable technology deployment … in 2021, renewable electricity generation achieved 48% and it is expected for this percentage to significantly grow in the next years") show higher numbers in the responses that indicate paying an **additional 3% or 6%**.

This leads to thinking that a negative frame might make the consumer lead to thinking they should increase their efforts to offset the pessimistic outlook. Therefore, this survey would lead recommendations to be based on showing the consumer a pessimistic perspective, focusing on raising awareness rather than a positive outlook.

It might be the case that an optimistic outlook of renewable deployment and CO_2 emissions reduction makes the respondent feel a moderate effort is enough to achieve the sustainable goals for the following years.

Correlation with other variables

The Spearman's correlation of the items to test (sustainability framing, loss aversion, risk aversion and willingness to change habits) is tested against the rest of the variables in the survey (see "Annex IV. Statistical tests" for further details on correlation coefficients for every pair of variables in the survey and their correspondent p-value).

Specifically, the willingness to pay for a company that offers 100% renewable energy (Q2, Q4) seems to be positively correlated with the environmental attitude scale results for all the questions of the scale (Spearman's $\rho = 0.247$, p-value < 0.001 for scale_media, Spearman's $\rho = 0.271$, p-value < 0.001 for scale_pollution, Spearman's $\rho = 0.2221$, p-value < 0.001 for scale_children, Spearman's $\rho = 0.264$, p-value < 0.001 for scale_science). This is an expected result, as the interest for renewable energies falls into the environmental awareness topics.

In addition to this, the matrices show positive but weak correlations between WTP and not being the person in the household paying the bills (Spearman's $\rho = 0.217$, p-value < 0.001), not receiving the social subsidy or "bono social" (Spearman's $\rho = 0.193$, p-value $= 0.003$) and a large number of people in the household (Spearman's $\rho = 0.148$ p-value $= 0.024$).

On the other hand, the willingness to pay is negatively correlated with age (Spearman's $\rho = -0.213$, $p = 0.001$), although again the correlation is considered weak.

Therefore, the profile of a consumer that shows a higher willingness to pay for a retailer with Guarantees of Origins would have the following features: they would be an adult or elderly person, would not be the payer of the electricity bill, would live in a house with more people and would not receive "bono social". The latest characteristic is especially insightful, as "bono social" can only be perceived if the contract follows the PVPC scheme and is connected to one of the last resort retailers. PVPC discloses the technologies for energy generation but cannot offer Guarantees of Origin in any case, as the energy comes from the pool, where technologies match without being constrained by their level of CO_2 emissions. Therefore, if a consumer is interested in 100% renewable energy, they would disregard PVPC and "bono social", which is what the survey is suggesting. **However, since all correlations are very weak (no pair of variables show a Spearman's ρ above 0.3), no firm resolutions can be extracted from the analysis.**

One-Way ANOVA tests

One-Way ANOVA of the items to test (sustainability framing, loss aversion, risk aversion and willingness to change habits) is performed to study if the differences between respondents for every question grouped by a series of grouping variables ("age", "gender", "tariff", "bonus" and "vulnerable") show significant differences in variance of average values (see "Annex IV. Statistical tests" for further details).

In the case of sustainability framing or WTP, it is determined that **no grouping variable shows significant results** ("age" $p = 0.084$, "gender" $p = 0.291$, "tariff" $p = 0.967$, "bonus" $p = 0.165$, "vulnerable" $p = 0.979$) of difference in variance.

8.2.2. Loss aversion

Loss aversion is tested in two questions: "Q6: Have you thought about changing your electricity retailer in the past 12 months?" and "Q7: Do you think you could be paying a cheaper electricity bill if you changed the electricity retailer or the tariff in your current electricity retailer?".

Responses for Q6 and Q7

The responses gathered for these two questions in the survey are displayed in Table 6:

Q6:" Have you thought about changing your electricity retailer in the past 12 months?"		*Q7: "Do you think you could be paying a cheaper electricity bill...?"*	
Yes	33%	Yes	49%
		No	40%
		Not my responsibility	1%
		Not know	10%
No	40%	Yes	23%
		No	67%
		Not my responsibility	2%
		Not know	7%
Not my responsibility	25%	Yes	15%
		No	7%
		Not my responsibility	75%
		Not know	3%
Not know	2%	Yes	20%
		No	0%
		Not my responsibility	0%
		Not know	80%

Table 6. Answers to Q6 ("Have you thought about changing your electricity retailer in the past 12 months?") and correspondent answers to Q7 ("Do you think you could be paying a cheaper electricity bill if you changed the electricity retailer or the tariff in your current electricity retailer?"). Source: own survey, author's own preparation. (2022).

- Around 33% of the respondents claim to have thought about changing their electricity retailer in the past 12 months. Focusing on the section of people that had thought about a change in electricity retailer, 49% think they could be paying a cheaper electricity bill.
- Around 40% of the respondents answer that they had not thought about changing their electricity retailer in the past 12 months. Out of this 40%, around 23% thinks they could be paying less. In other words, almost 1 out 4 people think that they could be paying less but have not considered changing retailer. This behavior does not match with the theory of the rational consumer: those who think they could be paying less should be actively looking for a new retailer, but some of them have not even considered that option. This result, however, fits in the loss aversion framework: the fear of abandoning a current situation (that is known not to be the optimal) surpasses the tendency to move to cheaper alternatives. In order to study which drivers promote loss aversion, the obstacles identified by respondents are discussed in the following paragraphs.

Obstacles Q12

Before treating the responses in the obstacles' question, a Principal Components Analysis is performed. As Q12 ("If you have ever thought about changing your electricity retailer,

have you identified any of the following obstacles?") allows the consumer to select more than one option, there is a risk of presenting alternatives that overlap (e.g. people who select "I do not know which types of tariffs exist" might tend to select "I think the process can take too much time" as well). The results of the test show that obstacles cannot be summarized in a fewer number of variables, as the main principal component displays a low percentage of variance explained (15.4%). See "Annex IV. Statistical tests" for further details on the PCA performed on obstacles.

The main obstacles identified when changing a retailer are:

1. "I do not know which types of tariffs exist" (~27%). This points out the lack of knowledge and the complexity of tariffs as barriers for rearranging the electricity retailer choice. It discloses that a relevant share of the respondents do not have a general knowledge of electricity tariffs in Spain.
2. "My current option has not given me any problems and I trust the company" (~23%). This answer is related to loss aversion, as respondents avoid moving to a cheaper alternative due to a current not optimal but comfortable situation.
3. "I do not fully understand the provided information" (~23%). Related to the first one, respondents show a lack of understanding of the details given by retailers. This entails information on webpage, phone enquiries in customer service, etc.

However, analyzing the same metrics for the respondents who answer "Yes" to Q7 and for the respondents who answer "No" to Q7, a clear distinction in the main obstacles encountered is observed.

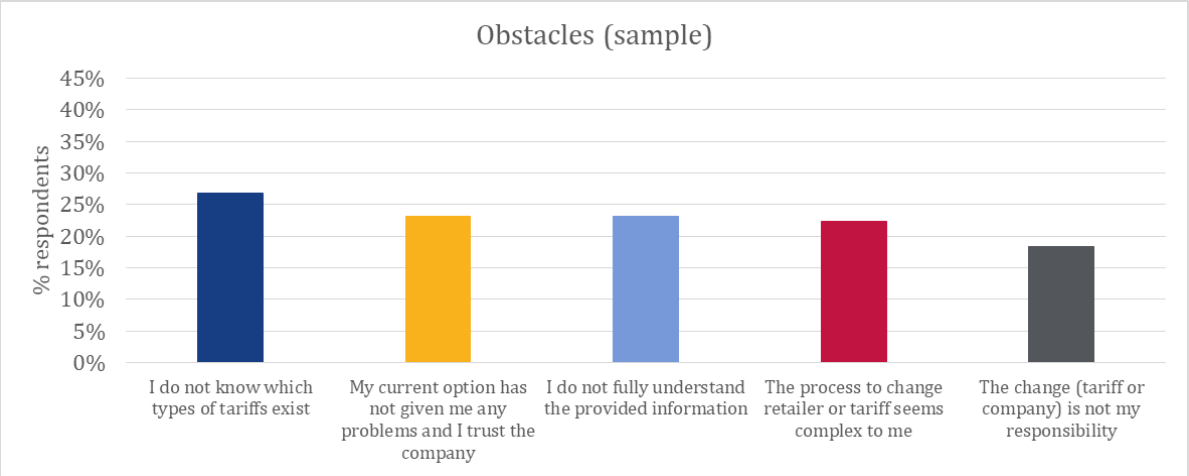

Figure 20. Top 5 obstacles when changing electricity retailer, taking whole sample. Respondents were allowed to choose more than one option. Source: survey, author's own preparation. (2022).

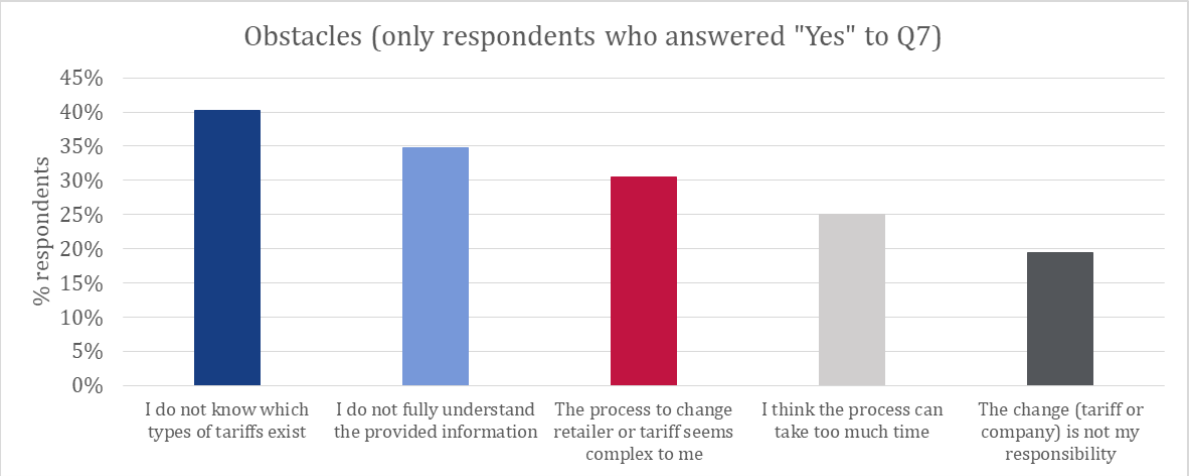

Figure 21. Top 5 obstacles when changing electricity retailer, taking only respondents that chose "Yes" in Q7 ("Do you think you could be paying a cheaper electricity bill if you changed the electricity retailer or the tariff in your current electricity retailer?"). Respondents were allowed to choose more than one option. Source: survey, author's own preparation. (2022).

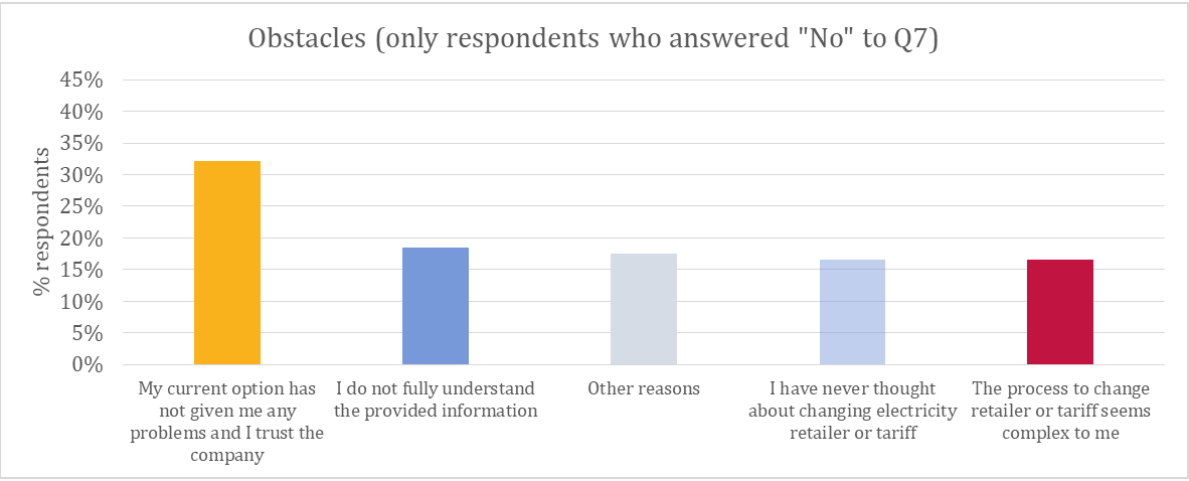

Figure 22. Top 5 obstacles when changing electricity retailer, taking only respondents that chose "No" in Q7 ("Do you think you could be paying a cheaper electricity bill if you changed the electricity retailer or the tariff in your current electricity retailer?"). Respondents were allowed to choose more than one option. Source: survey, author's own preparation. (2022).

As observed in Figure 21, focusing only on the respondents that think they could be paying less for their electricity bills, more than 40% claims a lack of knowledge regarding types of tariffs. They declare lack of understanding for the provided information and a perception of complexity. Hence, it is determined that education on electricity tariffs and simpler information in the offers is needed to unblock some consumers from their current situation (they think they could be paying less but do not know how to evaluate market options).

On the other hand, as observed in Figure 22, those respondents that think they could not be paying less for their electricity bills, mark different obstacles. The most frequent answer is that they did not have problems with their current option and trust the company, followed by a lack of understanding of the provided information. However, the "I do not know which types of tariffs exist" option seems to be overshadowed. Once again, this highlights the importance of default tariffs, as perception that the current option is good enough grows on some consumers and prevents them from exploring other alternatives.

Correlation with other variables

The Spearman's correlation of the items to test (sustainability framing, loss aversion, risk aversion and willingness to change habits) has been tested against the rest of the variables in the survey (see "Annex IV. Statistical tests" for further details on correlation coefficients for every pair of variables in the survey and their correspondent p-value).

Regarding loss aversion questions (Q6 and Q7), it is observed that **both variables seem to be positively correlated** (Spearman's $\rho = 0.434$, $p < 0.001$). This is an expected result as both questions were related to the loss aversion testing.

Focusing on "Q6: Have you thought about changing your electricity retailer in the past 12 months?", it is observed that "No"/"I do not know"/"Not my responsibility" responses to this question are positively but weakly correlated with: not being the payer of the electricity bill (Spearman's $\rho = 0.297$, $p < 0.001$), the professional status (Spearman's $\rho = 0.199$, $p = 0.002$), the type of the current tariff being PVPC or not knowing (Spearman's $\rho = 0.312$, $p < 0.001$) and not perceiving or not knowing about the "bono social" (Spearman's $\rho = 0.251$, $p < 0.001$).

On the other hand, responses to Q6 are negatively and weakly correlated with: age (Spearman's $\rho = -0.201$, $p = 0.002$), the responses in Q9 Willingness to change habits (Spearman's $\rho = -0.161$, $p = 0.014$), one of the questions of the environmental attitude scale (scale_science, Spearman's $\rho = -0.151$, $p = 0.021$) and the academic level (Spearman's $\rho = -0.130$, $p = 0.047$).

Focusing on "Q7: Do you think you could be paying a cheaper electricity bill if you changed the electricity retailer or the tariff in your current electricity retailer?", it is observed that "No"/"Not know"/"Not my responsibility" responses to this question are positively but weakly correlated with: the type of the current tariff being PVPC or not knowing (Spearman's $\rho = 0.178$, $p = 0.006$), not perceiving or not knowing about the "bono social" (Spearman's $\rho = 0.210$, $p = 0.001$), being a woman (Spearman's $\rho = 0.135$, $p = 0.039$) and not being the payer of the electricity bill (Spearman's $\rho = 0.131$, $p = 0.045$).

However, again, **correlation is too weak for all the pairs studied in this section to draw firm conclusions**.

One-Way ANOVA tests

One-Way ANOVA of the items to test (sustainability framing, loss aversion, risk aversion and willingness to change habits) is performed to study if the differences between respondents for every question grouped by a series of grouping variables ("age", "gender", "tariff", "bonus" and "vulnerable") show significant differences in variance of average values (see "Annex IV. Statistical tests" for further details).

In the case of the first question related to loss aversion, Q6, the results obtained are: "age" $p = 0.004$, "gender" $p = 0.132$, "tariff" $p < 0.001$, "bonus" $p < 0.001$, "vulnerable" $p = 0.471$. Thus, the **grouping variables that show highest significance are "bonus" and "tariff", followed by "age"**.

Regarding the second question related to loss aversion, Q7, the results obtained are: "age" $p = 0.017$, "gender" $p = 0.035$, "tariff" $p = 0.025$, "bonus" $p = 0.004$, "vulnerable" $p =$

0.287. Therefore, **"bonus", "tariff" and "age"** are again **significant grouping variables**, although in this case **"gender" is also considered**.

Deep dive on PVPC vs free market Q10

As explained in 2.1, PVPC stands for "Precio Voluntario para el Pequeño Consumidor" and is a last resort tariff that applies to almost 11 million consumers in Spain (18).

Combining the results for Q10 and Q7, the following results are obtained:

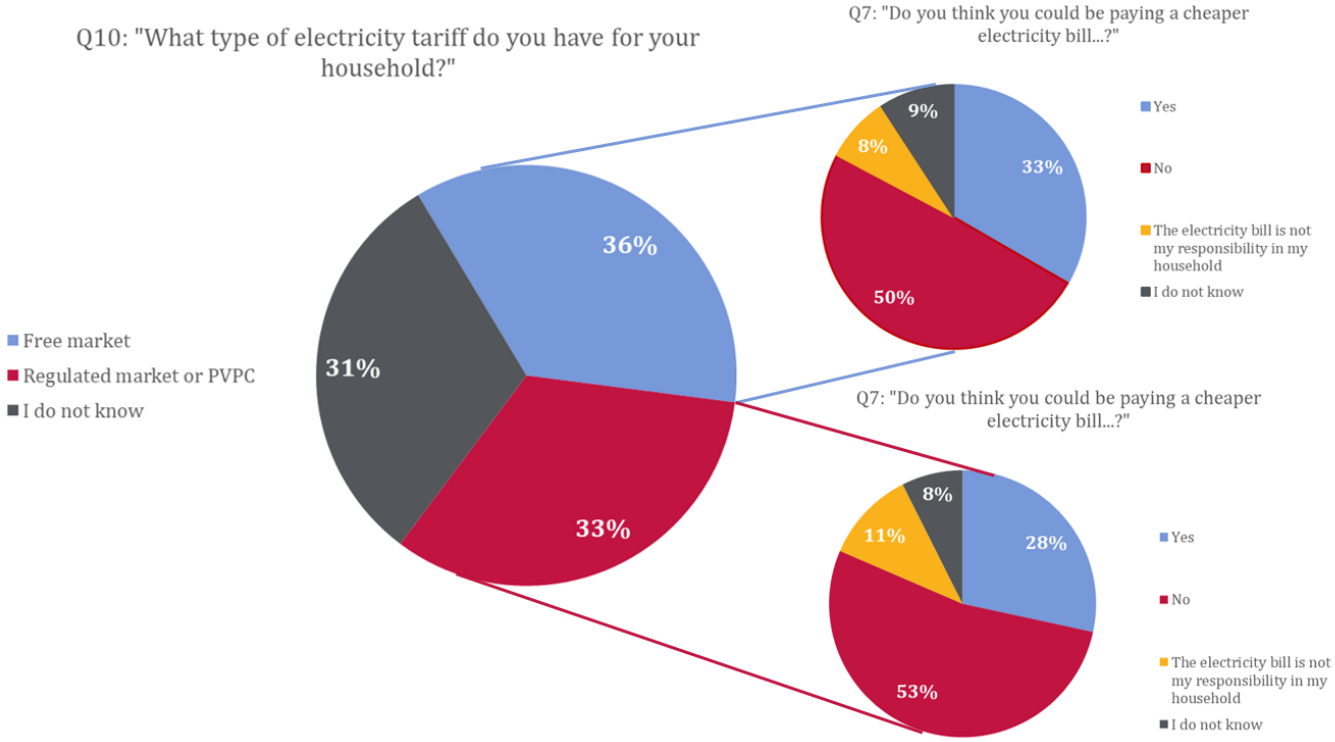

Figure 23. Answers to Q10 ("What type of electricity tariff do you have for your household?") and correspondent answers to Q7 ("Do you think you could be paying a cheaper electricity bill if you changed the electricity retailer or the tariff in your current electricity retailer?"). Source: own survey, author's own preparation. (2022).

As shown in Figure 23:

- Around 36% of the sample declares their household have a free market tariff. Focusing on these respondents, we can observe 33% thinks they could be paying a cheaper electricity bill and 50% thinks the opposite.
- Around 33% of the sample claims to have PVPC as their current tariff. Focusing on these respondents, we can observe 28% thinks they could be paying a cheaper electricity bill and 53% thinks the opposite.
- The remaining 31% of the sample answers "I do not know" when asked about their electricity tariff.

It seems like consumers that enjoy a regulated market / PVPC tariff tend to think they could not be paying less. A χ^2 hypothesis test is applied to the groups and the results indicate that the groups **(free market vs PVPC vs Not know) show significant differences in their responses to the question "Do you think you could be paying a**

cheaper electricity bill if you changed the electricity retailer or the tariff in your current electricity retailer?" ($p < 0.001$, see further details in "Annex IV. Statistical tests").

	Value	*df*	*p*
χ^2	34.6	6	< .001
N	233		

Table 7. χ2 test for differences in Q7 depending on Q10. Source: own survey, Jamovi. (2022).

8.2.3. Risk aversion

Risk aversion is tested in one question: "Q8: Assume you have to choose a retailer for your household. Company 1. It offers a fixed 100 €/month tariff. Your bill will always be that amount, regardless of your consumption or the different consumption hours. Company 2. It offers a variable tariff. You know there is an 87.5% probability of ending up paying 80 €/month. There is also a 12.5% probability of ending up paying 160 €/month. You will not know your final debt until you receive the bill. Which one would you prefer?".

Responses for Q8

As explained in 7.4, the rational consumer would prefer Company 2, as probabilistically it means a cheaper option.

However, as shown in Figure 24, more than half the respondents (56%) choose Company 1. Less than 40% choose Company 2 and the rest are either indifferent or do not understand the question.

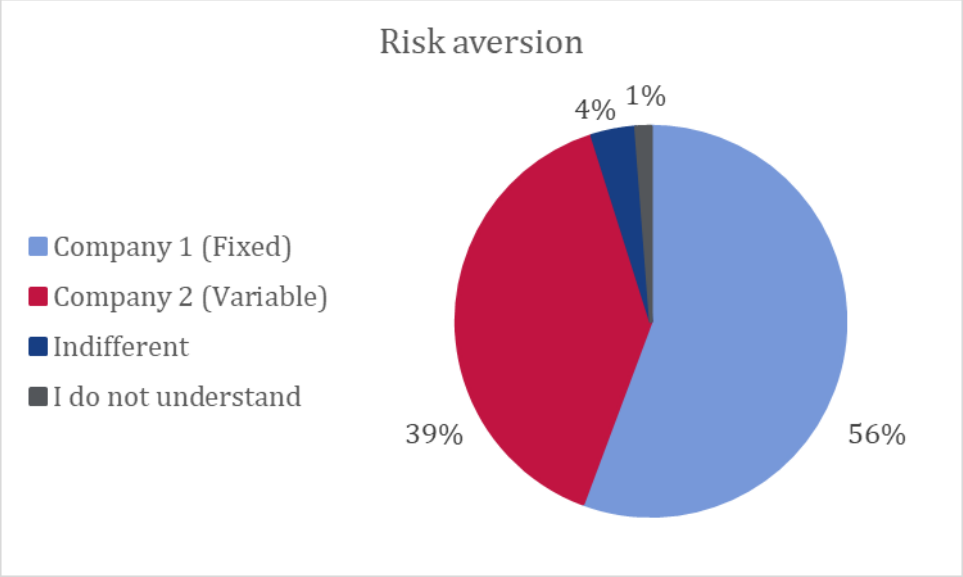

Figure 24. Responses for Q8 ("Assume you have to choose a retailer for your household…"). Source: own survey, author's own preparation. (2022).

These results might be explained by risk aversion: there seems to be an irrational fear towards uncertainty among the respondents.

Correlation with other variables

As discussed in previous sections, risk aversion in individuals has proven to be correlated to wealth (6) (50). Other studies also suggest that other demographic variables such as age or academic level might be correlated with risk aversion as well (54) (12), although the literature in this field is not as extensive as the one that empirically proves wealth and (lack of) risk aversion.

In the current survey, risk aversion seems to be weakly but positively correlated with the willingness to change habits (Spearman's $\rho = 0.276$, $p < 0.001$) but not with any other variable. P-values for other factors, such as age ($p = 0.216$), gender ($p = 0.253$) or academic level ($p = 0.991$) are too high to consider any correlation with risk aversion under all the significant thresholds usually applied in the literature ($p < 0.05$, $p < 0.01$ and $p < 0.001$).

However, since all correlations are very weak (no pair of variables show a Spearman's ρ above 0.3), no firm resolutions can be extracted from the analysis.

One-Way ANOVA tests

One-Way ANOVA of the items to test (sustainability framing, loss aversion, risk aversion and willingness to change habits) is performed to study if the differences between respondents for every question grouped by a series of grouping variables ("age", "gender", "tariff", "bonus" and "vulnerable") showed significant differences in variance of average values (see "Annex IV. Statistical tests" for further details).

In the case of risk aversion, Q8, the results obtained are: "age" $p = 0.009$, "gender" $p = 0.252$, "tariff" $p = 0.147$, "bonus" $p = 0.207$, "vulnerable" $p = 0.130$. Thus, the only **grouping variable that shows significance is "age".**

8.2.4. Willingness to change habits

Willingness to change habits is tested in one question: "Q9: Assume you have to choose a retailer for your household. Company 1. It offers a fixed 100 €/month tariff. Your bill will always be that amount, regardless of your consumption or the different consumption hours. Company 2. It offers a variable tariff. You know if you change your habits and consume electricity at specific time periods, your bill will be about 50 €/month. However, if you consume in the most expensive hours, your bill will go up to 150 €/month. Which one would you prefer?".

Responses for Q9

More than 60% of respondents choose Company 2 as the option they would prefer, meaning that 6 out of 10 people in the sample would be willing to change their habits in order to obtain a cheaper bill.

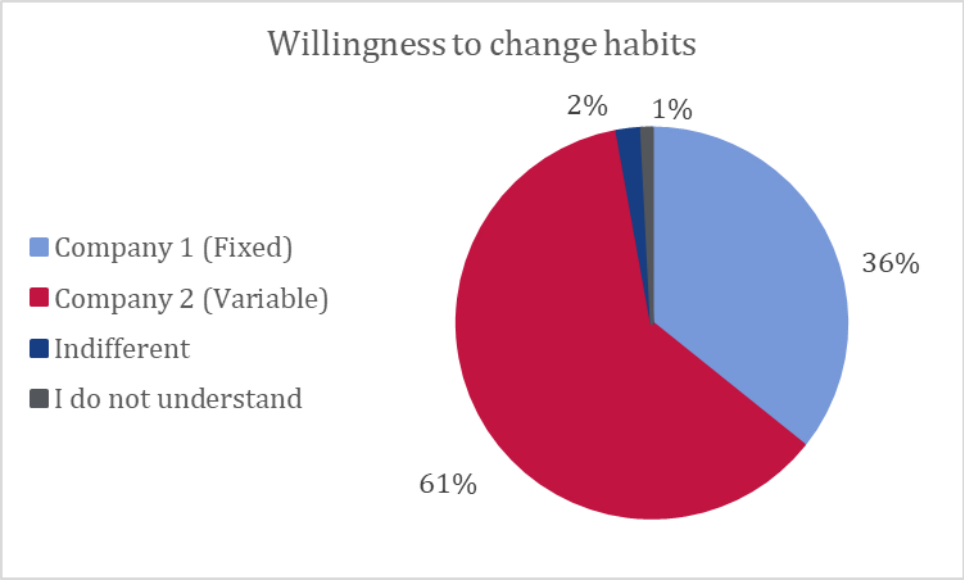

Figure 25. Responses for Q9 ("Assume you have to choose a retailer for your household…"). Source: own survey, author's own preparation. (2022).

Correlation with other variables

The Spearman's correlation of the items to test (sustainability framing, loss aversion, risk aversion and willingness to change habits) is tested against the rest of the variables in the survey (see "Annex IV. Statistical tests" for further details on correlation coefficients for every pair of variables in the survey and their correspondent p-value).

Regarding Willingness to change habits, it is observed that is positively correlated to risk aversion (Spearman's $\rho = 0.276$, $p < 0.001$), as it has been previously discussed, to the level of studies (Company 1 or fixed tariff tends to be preferred by lower academic levels, Spearman's $\rho = 0.133$, $p = 0.043$) and to all variables comprising the environmental attitude scale (scale_media: Spearman's $\rho = 0.169$, $p = 0.010$, scale_pollution: Spearman's $\rho = 0.1168$, $p = 0.010$, scale_children: Spearman's $\rho = 0.148$, $p = 0.024$, scale_science: Spearman's $\rho = 0.173$, $p = 0.008$). This seems to point out that respondents interested in changing their consuming patterns due to economic reasons (securing a cheaper bill) could also be motivated to change them for sustainable reasons.

On the other hand, there seems to be negative correlation towards the first variable measuring loss aversion, as it has been already discussed (Spearman's $\rho = -0.161$, $p = 0.014$), and the professional status (Spearman's $\rho = -0.190$, $p = 0.004$).

However, since all correlations are very weak (no pair of variables show a Spearman's ρ above 0.3), no firm resolutions can be extracted from the analysis.

A deep dive on the strongest correlation pair (WTC with risk aversion, Spearman's $\rho = 0.276$, $p < 0.001$) are be studied at the end of this subsection.

One-Way ANOVA tests

One-Way ANOVA of the items to test (sustainability framing, loss aversion, risk aversion and willingness to change habits) is performed to study if the differences between respondents for every question grouped by a series of grouping variables ("age", "gender",

"tariff", "bonus" and "vulnerable") showed significant differences in variance of average values (see "Annex IV. Statistical tests" for further details).

Regarding Willingness to Change Habits, Q9, the results obtained are: "age" p = 0.244, "gender" p = 0.879, "tariff" p =0.076, "bonus" p = 0.217, "vulnerable" p = 0.169. Thus, it is determined that **no grouping variable shows significant results**.

Deep dive on fixed vs variable tariffs

In both Q8 and Q9 the wording offered two companies: Company 1, offering a fixed tariff, and Company 2, offering a variable tariff. The difference between the two questions was that the variable tariff was dependent on different drivers: in Q8, a probability of paying more or less was given, while in Q9 the variable tariff would depend on the consumer's habits.

The results for Q8 and Q9 differ noticeably: while the fixed tariff was preferred by 56% of the candidates in Q8, only 36% of them chose the fixed tariff in Q9. **50% of the people who preferred a fixed tariff in Q8 changed to the variable tariff in Q9**.

Q8:"Assume you have to choose a retailer for your household". Fixed vs Probabilistic variable tariff.		*Q9: "Assume you have to choose a retailer for your household". Fixed vs habits variable tariff.*	
Company 1 (Fixed)	56%	Company 1 (Fixed)	48%
		Company 2 (Variable)	50%
		Indifferent	1%
		Not understand	0%
Company 2 (Variable)	39%	Company 1 (Fixed)	19%
		Company 2 (Variable)	79%
		Indifferent	2%
		Not understand	0%
Indifferent	4%	Company 1 (Fixed)	44%
		Company 2 (Variable)	44%
		Indifferent	12%
		Not understand	0%
Not understand	1%	Company 1 (Fixed)	0%
		Company 2 (Variable)	33%
		Indifferent	0%
		Not understand	67%

Table 8. Answers to Q8 ("Assume you have to choose a retailer for your household". Fixed vs Probabilistic variable tariff.") and correspondent answers to Q9 Assume you have to choose a retailer for your household. Fixed vs habits variable tariff". Source: own survey, author's own preparation. (2022).

A McNemar test is performed to study the change in proportions in the different alternatives (see "Annex IV. Statistical tests" for further details). The results ($p < 0.001$) manifest that **there is indeed a change in proportions from Q8 to Q9**.

Thus, it is determined that consumers could be attracted by variable tariffs when the final total amount to pay is influenced by their habits.

8.3. External validation

In order to understand the similarities between the gathered sample and the population (people living within the Spanish territory in 2022), a brief analysis of demographic resemblances is exposed in the following lines.

Around 53% of the sample is female, closely mirroring data for Spanish residents (71).

Age in the sample vs in Spanish official database for residents is shown below:

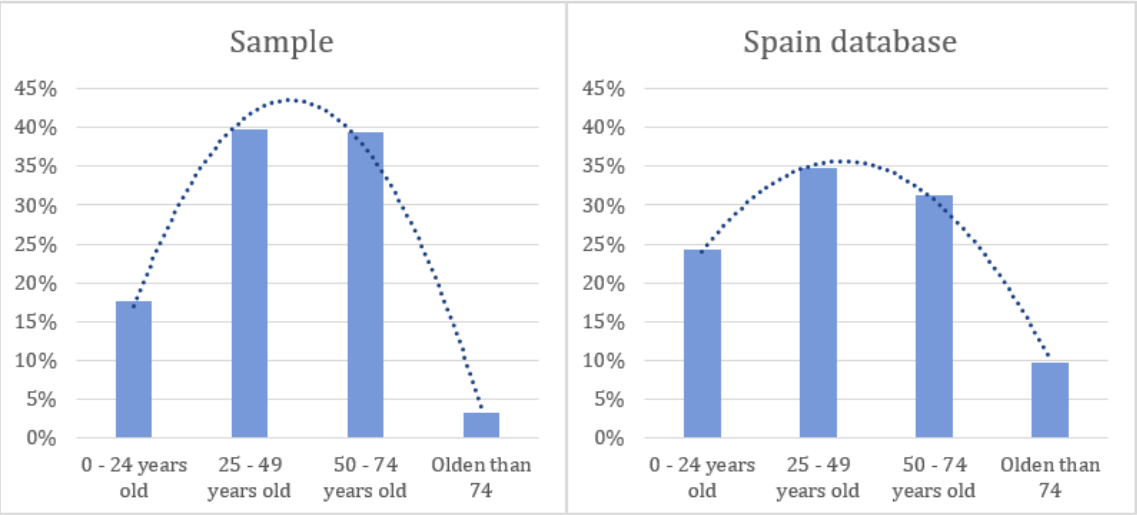

Figure 26. Age distribution in simple vs Spain database. Sources: own survey, (72). (2022).

The charts show that the sample concentrates larger shares in the 25 – 49 and 50 – 74 years old groups, meaning 0 – 24 and Older than 74 groups might be under-represented.

Regarding labor force, it is observed that the percentage of working population in the sample (76%) is much higher than in Spain in official databases (49%). However, this might be a consequence of lack of young children and older people in the sample. Focusing on only on the 25 – 49 years old group, shares of working population for sample and Spain are almost identical (85.58% vs 85.75%).

The demographic characteristic that might cause larger distortions while extracting conclusions is the academic level. The survey sample shows significantly higher educational level than the Spain database by official administration entities. This feature needs to be taken into account while evaluating the external validity of the experiment and when drawing general conclusions, as educational level might be a strong bias for some of the questions.

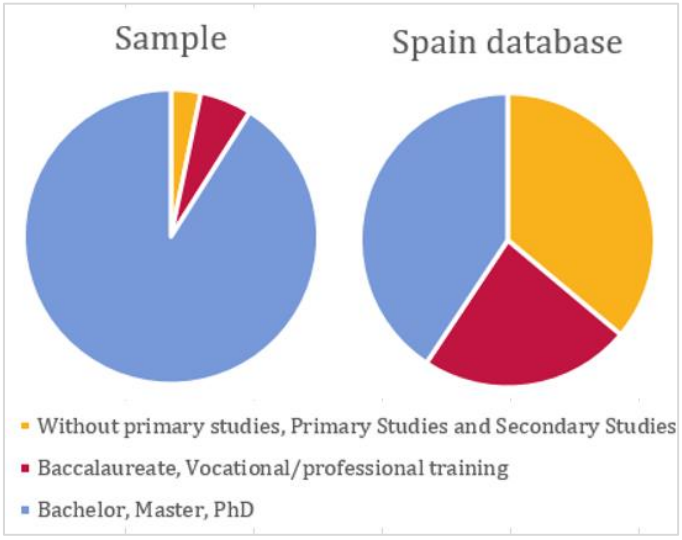

Figure 27. Academic level in sample vs Spain database. Sources: own survey, (73). (2022).

One of the drivers of this unbalance might be the lack of individuals in the older groups of the sample, as trends indicate that older people correlate with lower academic levels.

Therefore, it is determined that the experiment should have had a higher degree of representativeness in the older groups and lower educational level groups (which might overlap). However, sample seems to be representative of Spanish population in the intermediate groups of age. This affects external validation: level of validation for unrepresented groups is lower than for those that mirror Spanish society according to official sources.

8.4. Comparison with other studies

In previous sections, other studies related to the four elements to test are named. In the following paragraphs, a discussion of the similarities of these studies is included.

8.4.1. Sustainable framing and Willingness to Pay

Previous research claim that "consumers displayed stronger intention to buy 'green energy' when the situation was framed in a positive manner" (7), considering framing a determinant for the price consumers would be accepting for eco-labeled energy (8).

In this case, the effect of the framing seems to be the opposite one: those respondents who receive the negative framing state a higher willingness to pay ($p = 0.044$). It is important to notice that the p-value might indicate results are not significant on certain standard thresholds in literature. Thus, although results from the present survey contradict previous research, the opposition is not clear enough to draw firm conclusions.

8.4.2. Loss aversion

In the case of the second element to test, loss aversion, literature provides some statements:

- Loss aversion is one of the causes to underrate energy efficiency (10).
- One of the explanations for the "energy efficiency gap" or "energy paradox" that prevents consumers from choosing the most cost-effective decisions is loss aversion (14).
- The correlation of loss aversion to a less-likely attitude to adopt energy-efficient technologies (11).

In the present study, loss aversion is observed: 33% of the respondents that have not considered changing electricity retailer in the past 12 months think they are not enjoying the most cost-effective decision. However, correlation with a change in energy behaviors (with the willingness to change habits variable) is not observed ($p = - 0.161$, $p = - 0.115$), as suggested by (11).

8.4.3. Risk aversion

Risk aversion is also present in previous research, indicating:

- There might be evidence to support risk aversion is positively correlated with age or other household characteristics (12), according to a study circumscribed to a Swedish sample.
- A potential driver of risk aversion in households is national culture (13), according to literature that compares Singapore and German respondents.
- The correlation of risk aversion to a less-likely attitude to adopt energy-efficient technologies (11).

In the present study, national culture is not defined, as the totality of the targeted sample is located in Spain.

On the other hand, no strong correlation has been found to support the evidence that risk aversion is correlated with age (Spearman's $\rho = -0.082$, $p = 0.216$). Some moderate correlation of risk aversion and attitudes prone to change habits is found (Spearman's $\rho = 0.276$, $p < 0.001$).

8.4.4. Willingness to Change Habits

Research on shifting household energy to more efficient patterns shows that consumers find common obstacles: lack of information, administrative problems, non-user-friendly technologies, complexity and lack of awareness (15) (16) (17).

The study shows that 61% of the sample would be willing to change their consumption patterns if that behavior translated into a cheaper electricity bill. This suggests that maybe the economic incentive of a cheaper bill could be a driver to overcome the obstacles towards cheaper and more efficient consumption patterns.

9. Conclusions

The motivation of this project is to understand the drivers behind the decision-making process around tariffs in electricity among Spanish households. In order to do so, a survey is presented to 246 respondents with a focus on four elements to test (sustainable framing and willingness to pay, loss aversion, risk aversion and willingness to change habits) and the potential influence of current supplier choices and demographic factors. With the data obtained from the questionnaire, an analysis is carried out to extract results on these four elements, taking special consideration of PVPC consumers and the perception of fixed and variable tariffs.

The experiment requires a minimum of 128 respondents (64 people for each framed group) to reach a power ($1 - \beta$ error probability) of 80%. As the survey gathers 246 people, it is determined that the sample size requirements are fulfilled.

A series of controls are applied to the sample:

- A manipulation check is employed to exclude participants that do not understand the framing.
- A randomization test is performed to determine if the groups show significant differences. It is determined that randomization is correctly applied (for $\alpha = 0.05$).
- Priming effect is also studied (i.e. understand if sustainable framing affects other questions in the survey). Results of test indicate that no priming effect takes place (for $\alpha = 0.05$).
- Measure of reliability of the environmental attitude scale exceeds 0.7 in the Cronbach's α. Thus, it is determined that the scale shows adequate reliability.
- A PCA is applied as well to study Common Method Bias. The low percentage of variance explained by the first component (11.66%) indicated that Common Method Bias is not discernible in the sample.

Similarities between the survey respondents (sample) and Spanish consumers (population) are studied as well in order to understand if extrapolation of results to population might be applicable. It is determined that the sample mirrors the population in terms of gender, but finds some mismatch regarding age, working population and educational level. It is resolved that the sample seems representative working consumers of intermediate groups of age with high educational level.

Sustainable framing and willingness to pay

The sample is split into two groups. One group is exposed to positive sustainable framing (high share of renewables in the system and expected growth of this metric) and the other group receives negative sustainable framing (a handful of companies emitting the majority of CO_2 emissions, barriers to impact the bigger picture as a consumer).

The results of the t-Student indicate that there is some influence by the framing on the groups, as those who receive the negative treatment are more willing to pay an additional 9% price in their bill for a 100% renewable energy supply. On the other hand, those who

receive the positive treatment tend to answer they would pay only an additional 3% or 6% price in their bill.

When studying the correlation to other variables, it is exposed that no other factors seem to influence this question.

Loss aversion

Only 1 out of 3 people (33%) have considered changing their electricity retailer in the past 12 months. Around 1 of 4 people (23%) that have not considered changing electricity retailer in the past 12 months thinks they could be paying a cheaper electricity bill.

More than 30% of those that think they could not be paying a cheaper bill claim their current option has not given them any problems and they trust the company. On the other hand, those who think could be paying a cheaper electricity bill highlight the ignorance about types of tariffs (40%).

It is also interesting to highlight that a larger share of consumers with PVPC tariff think they could not be paying a cheaper electricity bill.

While both questions about loss aversion are correlated no strong correlation is found when paired with demographic variables.

Risk aversion

Risk aversion is tested in one question. Respondents have to choose between a fixed and a variable tariff. A probability of the possible outcomes of their bill is given. It is important to note that the rational consumer would prefer the variable tariff, as the probabilistic outcome of paying a cheaper bill is higher.

However, results show that only 39% of the respondents prefer the variable tariff.

Willingness to Change Habits

More than 60% of the respondents choose the variable tariff as the option they would prefer, meaning that 6 out of 10 people in the sample would be willing to change their habits in order to obtain a cheaper bill. Around 50% of the people who preferred a fixed tariff in the risk aversion question changed to the variable tariff in this one, meaning a variable tariff is preferred when the outcome of the bill is dependent on consumer behavior.

Final remarks

Thus, combining the conclusions of all the elements tested in the survey, the results of the analysis indicate that:

- Sustainable framing has some effect on the willingness to pay for 100% renewable energy by consumers.
- When respondents are given the choice to opt for a variable or fixed tariff, the variable tariff is avoided when the bill depends on something out of the consumer's control, even though it is probabilistically cheaper. However, the variable tariff is preferred when the consumer can decrease the final price by

changing their consumption habits (consuming energy at certain periods of time during the day).

- Demographic factors such as age, gender, etc. do not seem to influence the decision making process regarding electricity-related decisions.

Understanding the limitations of the project and the potential new dimensions future research might focus on, a list of points to address hereafter on the topic is presented below:

- One of the main issues regarding external validity of the survey comes from the insufficient representation of certain groups in the sample, namely people older than 74 years old and consumers whose higher educational level is primary or secondary studies. Even though some data points for these collectives are present in the survey, not enough to mirror the Spanish population were included. As all the distribution channels considered online means (open blogs, social media, email, etc.), the technological barrier might have been an obstacle for elderly people and low academic level consumers. A potential solution to this might be increase the survey distribution channel to in-person questionnaires.
- The survey presented in the current project was not limited to any consumer. However, for future studies, it might be beneficial to circumscribe the targeted sample to consumers that pay the bill in their household or are responsible for the choice of retailer or tariff.
- Even though the academic level and professional status are items of the survey presented in the current project, a deeper understanding of these might be advantageous. Specifically, asking consumers if their academic background or professional occupation is related to the electricity sector.

Finally, some suggestions and proposals are listed in the following paragraphs.

The goal of these suggestions is not to comprise detailed instructions on how to inform the population or modify the default tariff in Spain, but to present a series of guidelines to help shape the approach to consumers in Spain.

Tariff proposals and adoption of low CO_2 technologies

As explained previously, PVPC is the default tariff in Spain and is agnostic to the energy source that supplies consumers. It is a one-kind variable tariff highly dependent on the wholesale electricity market. It does not allow to opt for a 100% renewable energy supply or any other special circumstance regarding generation technologies.

However, the survey points out that more than 50% of the sample would be willing to pay at least an additional 3% price in their electricity tariff to ensure the electricity source to come from renewable sources.

The additional price consumers would be willing to pay increases when receiving a certain framing. In this project, that negative or pessimistic framing that raises awareness about the current emissions seems to lead to a higher WTP for renewable energy sources.

Considering these remarks, it is safe to say that with the adequate framing and a wider range of options for tariffs, a potential mass of consumers would be willing to pay for

renewable energy for their household. This additional price could be partly redirected to the renewable energy producers in the energy wholesale market, encouraging an incentivizing effect. Regulation that guarantees that indeed green tariffs are true should be closely supervised to avoid mistrust and frauds.

Common obstacles to making an informed decision

When asked about considering a change in their electricity retailer, the most frequent answers of the sample are:

1. "I do not know which types of tariffs exist" (27%).
2. "My current option has not given me any problems and I trust the company" (23%).
3. "I do not fully understand the provided information" (23%).
4. "The process to change retailer or tariff seems complex to me" (22%).

Focusing on the people who believe they could be paying less for their electricity bill, statements 1, 2 and 4 skyrocket (41% do not know which types of tariffs exist, 35% do not understand the provided information and 31% believes the process to change retailer or tariff seems complex).

Therefore, it seems clear that a greater effort regarding education in the electricity sector is needed.

Current tools available to the general public to better understand the electricity tariff include:

- Energy offers comparing tool ("Comparador de Ofertas de Energía") by CNMC. This website allows the consumer to easily check different electricity and natural gas retailers regarding type of tariff, if retailers offer renewable supply, an estimated bill for the two following years and if the consumer can buy additional services. However, implementing the regulatory changes of the last months in the tool takes months, making the tool unavailable for consumers during long periods of time.
- Some slide decks are also uploaded to CNMC webpage (75). These decks comprise basic concepts about the electricity bill and how domestic consumers could be affected by new regulation, although they focus only on access tolls.
- Guide to understand your electricity bill by OCU and Frequent Asked Questions. As an independent organization to inform consumers, OCU published reports and articles about how to understand the electricity bill. However, many of the articles are outdated and do not explain the current tariffs and special circumstances that apply since special measures due to Ukraine were applied (76) (77) (78).
- Basic guide to interpret the electricity bill ("Guía práctica para saber interpretar la factura de la luz") by Comunidad de Madrid (79).

Some recommendations to increase electricity education in the population are:

- Update official webpages by official bodies, showing the latest information. This would prevent contradictory information in the different webpages. For the webpages that are already updated, create awareness of their existence (campaigns, include adequate key words so search for them on browsers is eased, etc.).
- Create a standard template for free market retailers, pointing out how some concepts of the bill should be presented to the consumer. There is a template for last resort retailers that eases the bill understanding, but no established format is applied to free market tariffs. As PVPC consumers also point out obstacles regarding lack of information and understanding, include explanations or links to guides and videos to understand basic concepts.
- Create a guide with the basics of how to estimate the electricity bill. "Comparador de Ofertas de Energía" by CNMC should do this, but maintenance periods might risk consumers to be unable to forecast estimations.
- Compel retailers to inform about last resort tariffs and social subsidy ("bono social") when marketing new offers to clients.

Forecast on prices

The development of applications for consumers to provide price forecast can help them to program their flexible loads in advance. For example, In France, ÉcoWatt (80) is a platform by RTE (French TSO) that establishes forecasts for electricity demand for the following days. ÉcoWatt sends an alert to consumers when forecast announces peaks in demands, requesting consumer help to smooth them by switching their consumption to other periods in the day. Although the ultimate goal of this services is to prevent the system to be exposed to extreme situations where load shedding might be needed due an exceptional peak in demand, an indirect advantage is a reduction in wholesale prices. The reason for this is that the most expensive technologies that are matched in a peak of demand would lose their bids against a smooth demand through the day.

A similar service could be provided to consumers in Spain. Since 61% of the sample declared that they would be willing to change their consumption patterns if that meant a discount in their electricity bill, a potential application of this service seems promising.

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Annex I. SDGs framework

The Sustainable Development Goals are a blueprint presented by United Nations and set to be fulfilled by 2030 whose main objective is to achieve a better and more sustainable future for all. There are several goals within this framework that are related to the development of this project.

The Goal number 7, "Affordable and Clean Energy", is specially allied with the topic of the present TFM. It entails the following targets[10]:

7.1. Universal access to modern energy

7.2. Increase global percentage of renewable energy

7.3. Double the improvement in energy efficiency.

7.4. Promote access to research, technology and investments in clean energy.

The project deals with the affordability of energy supply, the impact of renewable energies in the electricity bill and the perception of consumers regarding different suppliers and the components of the electricity price, especially in the PVPC.

Figure 28. Sustainable Development Goals: 7. Source: United Nations, (2022)[11].

However, some other Goals are also included indirectly.

- SDG 3 "Good health and well-being", as electricity covers basic needs, as lighting and keeping an adequate temperature in a household.
- SDG 11 "Sustainable cities and communities", since electrification is a process many modern cities will go through in the following years in order to achieve decarbonization targets.
- SDG 10 "Reduced inequalities", as vulnerable consumers and the application of the social subsidy ("bono social") are also studied in the survey and in the analysis of the sample.

[10] https://www.globalgoals.org/goals/7-affordable-and-clean-energy/
[11] https://sdgs.un.org/goals

Figure 29. Sustainable Development Goals: 3, 11 and 10. Source: United Nations, (2022).

Section 9 includes suggestions and proposals aimed at policy makers and retailer companies in the electricity sector. These are intended to make the offers more understandable by the average consumer, in order for them to be able to make an informed decision, towards a cheaper and more sustainable tariff.

Annex II. Spanish questionnaire

Evaluación de la opinión de los consumidores sobre las tarifas de electricidad

¡Hola! Me llamo María Pérez-Tabernero y soy alumna del Máster de Ingeniería Industrial de la Escuela Técnica Superior de Ingeniería ICAI (Universidad Pontificia Comillas). Como parte de mi Trabajo de Fin de Máster, estoy realizando una investigación sobre la opinión y percepción de los consumidores acerca de las tarifas de electricidad en España.

Responder a la encuesta le tomará unos 8 minutos.

Se ruega que únicamente se responda una vez a la encuesta. Por favor, pulse el botón de "Enviar" al final de la encuesta para registrar su respuesta.

Algunas preguntas son obligatorias (*).

Si tiene cualquier pregunta, no dude en contactar al siguiente email: 201600979@alu.comillas.edu

Muchas gracias de antemano por su tiempo.

Antes de empezar, por favor, lea la siguiente información:

1. La participación en este cuestionario es voluntaria y responder a este cuestionario no conlleva ningún beneficio o riesgo para usted.

2. Al pulsar el botón "Enviar" al final de la encuesta, da usted su consentimiento para el trato de sus respuestas de forma anónima. La información recogida será tratada de forma agregada y no se le pedirán datos personales.

Introducción

1. El día de su nacimiento, ¿es una fecha par o impar? *

   Marca solo un óvalo.

   - Par
   - Impar

Pares

2. Una de las principales herramientas para reducir las emisiones de dióxido de carbono son las tecnologías renovables (solar, eólica, etc). Según Red Eléctrica de España, en 2021, la generación de electricidad renovable en la península alcanzó el 48% y se espera que este porcentaje crezca en los próximos años de manera significativa.

   Fuente: https://www.sistemaelectrico-ree.es/sites/default/files/2022-08/InformeSistemaElectrico_2021.pdf

   Suponga que debe elegir entre una de las siguientes compañías.

   Compañía 1. No revela el origen de su energía. Puede ser renovable o no.

Compañía 2. Afirma que el 100% de su energía tiene garantías de origen renovable. ¿Pagaría más por contratar a la Compañía 2 para el consumo de su hogar? *

Marca solo un óvalo.

- o No
- o Pagaría hasta un 3% más
- o Pagaría hasta un 6% más
- o Pagaría hasta un 9% más
- o Pagaría más de un 9% adicional
- o No entiendo la pregunta

Pares (continuación)

3. El texto anterior hablaba de… *

Marca solo un óvalo.

- o Vehículos eléctricos
- o Generación de electricidad a partir de fuentes renovables en España y tarifas
- o Legislación en materia de electricidad

Impares

4. Según un estudio realizado en 2017, hay una lista de 100 compañías que, en conjunto, son culpables del 71% de las emisiones de dióxido de carbono a la atmósfera desde 1988. Estos datos empujan a pensar que las decisiones de los consumidores no afectan realmente el panorama global.

   Compañía 1. No revela el origen de su energía. Puede ser renovable o no.

   Compañía 2. Afirma que el 100% de su energía tiene garantías de origen renovable.

   ¿Pagaría más por contratar a la Compañía 2 para el consumo de su hogar?

   Marca solo un óvalo.

   - o No
   - o Pagaría hasta un 3% más
   - o Pagaría hasta un 6% más
   - o Pagaría hasta un 9% más
   - o Pagaría más de un 9% adicional
   - o No entiendo la pregunta

Impares (continuación)

5. El texto anterior hablaba de… *

Marca solo un óvalo.

- Vehículos eléctricos
- Generación de electricidad a partir de fuentes renovables en España y tarifas
- Legislación en materia de electricidad

Preferencias

6. ¿Ha estado pensando en cambiar su compañía comercializadora de electricidad en los próximos 12 meses?

   Nota: la compañía comercializadora de electricidad es aquella que le envía facturas. Algunos ejemplos son Endesa, Holaluz, Total Energies, Iberdrola, Naturgy…

   Marca solo un óvalo.

   - Sí
   - No
   - No me responsabilizo de la factura de la electricidad en mi hogar
   - No sé

7. ¿Cree que podría estar pagando menos por la factura de electricidad si cambiara de compañía o si cambiara la tarifa con su actual compañía?

   Nota: la compañía comercializadora de electricidad es aquella que le envía facturas. Algunos ejemplos son Endesa, Holaluz, Total Energies, Iberdrola, Naturgy...

   Marca solo un óvalo.

   - Sí, creo que podría estar pagando menos por mi factura con otra compañía o con otra tarifa
   - No, no creo que pudiera estar pagando menos
   - No me responsabilizo de la factura de la electricidad en mi hogar
   - No sé

8. Suponga que tiene que elegir entre una de estas compañías de electricidad para el consumo de su hogar.

   Compañía 1. Tiene una tarifa fija de 100€/mes. Siempre le cobrará esa cantidad sin importar su consumo ni las horas en las que consuma electricidad.

   Compañía 2. La tarifa que ofrece esta compañía depende de otros factores. Sabe que hay una probabilidad del 87,5% de que pague 80 €/mes. También hay una probabilidad del 12,5% de que acabe pagando 160 €/mes. No sabrá lo que tiene que pagar hasta que no le llegue la factura.

   ¿Cuál preferiría?

   Marca solo un óvalo.

- Compañía 1
- Compañía 2
- Indiferente
- No entiendo la pregunta

9. Suponga que tiene que elegir entre una de estas compañías de electricidad para el consumo de su hogar.

   Compañía 1. Tiene una tarifa fija de 100€/mes. Siempre le cobrará esa cantidad sin importar su consumo ni las horas en las que consuma electricidad.

   Compañía 2. La tarifa que ofrece esta compañía depende de las horas en las que consuma electricidad. Sabe que si cambia sus hábitos y consume a ciertas horas, su tarifa rondará los 50€/mes. Sin embargo, si acaba consumiendo en las horas más caras, su tarifa ascenderá a 150€/mes.

   ¿Cuál preferiría?

   Marca solo un óvalo.

   - Compañía 1
   - Compañía 2
   - Indiferente
   - No entiendo la pregunta

Consumidor

En esta sección se le presentarán varias preguntas sobre su tarifa y consumo actual. Intente responderlas sin mirar su última factura y sin buscar información externa (ej: buscar en internet).

10. ¿Qué tipo de tarifa eléctrica tiene en su hogar?

    Marca solo un óvalo.

    - Mercado libre
    - Mercado regulado o PVPC - Precio Voluntario para el Pequeño Consumidor
    - No sé

11. ¿Se está beneficiando actualmente del bono social?

    Marca solo un óvalo.

    - Sí
    - No
    - No sé si me estoy beneficiando del bono social
    - No sé lo que es el bono social

12. Si alguna vez se ha planteado cambiarse de compañía, ¿se ha sentido identificado con alguno de los siguientes obstáculos? Puede marcar más de una respuesta.

    Selecciona todos los que correspondan

    - ☐ Desconozco los tipos de tarifa
    - ☐ No sé cómo informarme sobre los tipos de tarifa
    - ☐ No entiendo completamente la información proporcionada
    - ☐ No tengo claro cómo contactar para solicitar el cambio de compañía
    - ☐ El proceso de cambio me parece complejo
    - ☐ Creo que el proceso puede tomar demasiado tiempo
    - ☐ Mi actual compañía no me ha dado problemas y confío en ellos
    - ☐ El cambio de compañía o tarifa no depende de mí (lo gestiona otra persona de mi hogar, por ejemplo)
    - ☐ Tengo que cumplir con un periodo de permanencia con mi actual compañía o tarifa
    - ☐ Otra razones
    - ☐ Nunca me he planteado cambiarme de compañía o tarifa

Datos demográficos

En esta sección, se le mostrarán preguntas sobre su edad, nivel de estudios...

13. Por favor, seleccione su rango de edad

    Marca solo un óvalo.

    - o 0 – 24 años
    - o 25 – 49 años
    - o 50 – 74 años
    - o Mayor de 74 años

14. Seleccione su género

    Marca solo un óvalo.

    - o Hombre
    - o Mujer
    - o Otro/prefiero no decirlo

15. Seleccione su nivel de estudios más alto, tanto si lo ha finalizado como si se encuentra actualmente cursándolo

    Marca solo un óvalo.

    - o Sin estudios primarios

- Estudios primarios / Educación primaria
- Estudios secundarios / ESO
- Bachillerato o equivalente
- Formación profesional
- Grado universitario o diplomatura
- Máster universitario, diploma de post grado o licenciatura
- Doctorado

16. Seleccione su actual situación profesional

Marca solo un óvalo.

- Trabajando por cuenta ajena o como autónomo (se incluyen en esta categoría las personas realizando becas o prácticas profesionales)
- Estudiando
- Estudiando y trabajando por cuenta ajena o como autónomo (se incluyen en esta categoría las personas realizando becas o prácticas profesionales)
- Jubilado
- Otro

17. ¿Cuántas personas viven en su hogar? (Incluyéndose a sí mismo)

Marca solo un óvalo.

- 1
- 2
- 3
- 4 o más

18. ¿Están las facturas de electricidad en su hogar a su nombre?

Marca solo un óvalo.

- Sí
- No, otra persona es la titular del contrato de electricidad
- No sé
- La factura de la electricidad es un concepto incluido en mi alquiler

19. ¿Aplica alguna de las siguientes condiciones a su hogar?

- El ingreso anual total es menor que 10.422,36 €

- Hay tres o más niños (se considera niño a toda persona menor de 18 años)

- Todas las personas del hogar reciben una pensión e ingresos adicionales por menos de 500 € al año

- Alguna de las personas del hogar recibe el Ingreso Mínimo Vital

Marque "Sí" si cumple alguna de las condiciones, no tiene porqué cumplir todas.

Marca solo un óvalo.

- Sí
- No
- No sé

Esta es la última sección. Recuerde darle a Enviar al finalizar

20. Los medios de comunicación han exagerado el problema ecológico

Marca solo un óvalo.

- 1. Muy en desacuerdo
- 2.
- 3.
- 4.
- 5. Muy de acuerdo

21. Si el ser humano quiere sobrevivir, debe parar la contaminación ambiental

Marca solo un óvalo.

- 1. Muy en desacuerdo
- 2.
- 3.
- 4.
- 5. Muy de acuerdo

22. Estoy preocupado/a por la oportunidad de los niños del futuro de vivir en un ambiente libre de contaminación

Marca solo un óvalo.

- 1. Muy en desacuerdo
- 2.
- 3.
- 4.
- 5. Muy de acuerdo

23. No deberíamos preocuparnos por problemas medioambientales porque la ciencia y la tecnología pronto los solucionarán

Marca solo un óvalo.

- 1. Muy en desacuerdo

○ 2. ○ 3. ○ 4. ○ 5. Muy de acuerdo

Table 9. Spanish questionnaire. Source: author's own elaboration. (2022).

Annex III. English questionnaire

Consumer opinion on electricity tariffs

Hello! My name is María Pérez-Tabernero and I am a last-year student in the Industrial Engineering Master's degree in ICAI (Comillas Pontifical University).

My master thesis includes a field research about consumer opinion and perception on electricity tariffs in Spain.

Answering this survey takes about 8 minutes.

Please, answer the survey only once.

To properly save your response, click on "Send"/"Enviar" at the end of the survey.

Some questions are compulsory (*).

If you have any questions, feel free to contact 201600979@alu.comillas.edu.

Thank you in advance for your time.

Before starting, please read the following points:

1. Participation in this survey is voluntary and will not mean any harm or benefit for the participants.

2. When clicking on "Send"/"Enviar", you agree to the anonymous treatment of your data. Collected data will be treated in an aggregated way and no personal questions (email, name, ID...) will be asked.

Introduction

1. Is your birthday date odd or even? *

   Select only one option.

   - Even
   - Odd

Even

2. One of the main tools to decrease carbon dioxide emissions is renewable technology deployment (solar, wind, etc).

   According to Red Eléctrica de España, in 2021, renewable electricity generation achieved 48% and it is expected for this percentage to significantly grow in the next years.

   Source: https://www.sistemaelectrico-ree.es/sites/default/files/2022-08/InformeSistemaElectrico_2021.pdf

   Assume you have to choose between one of these companies:

Company 1. It does not disclose the origin of the energy they provide. It could be renewable or non renewable.

Company 2. It claims 100% of the energy they provide has renewable Guarantees of Origin. Would you pay more to choose Company 1?*

Select only one option.

- o No
- o Yes, I would pay up to an additional 3%
- o Yes, I would pay up to an additional 6%
- o Yes, I would pay up to an additional 9%
- o Yes, I would pay more than an additional 9%
- o I do not understand the question

Even (second part)

3. The previous text mentioned... *

   Select only one option.

   - o Electric vehicles
   - o Electricity generation using renewable technologies in Spain and tariffs
   - o Electricity legislation

Odd

4. According to a study that took place in 2017, there are 100 companies in the world that are responsible for 71% of the carbon dioxide emissions worldwide since 1988.

   This information leads to thinking that consumer decisions do not affect global outlook.

   Assume you have to choose between one of these companies:

   Company 1. It does not disclose the origin of the energy they provide. It could be renewable or non renewable.

   Company 2. It claims 100% of the energy they provide has renewable Guarantees of Origin.

   Would you pay more to choose Company 1?

   Select only one option.

   - o No
   - o Yes, I would pay up to an additional 3%
   - o Yes, I would pay up to an additional 6%
   - o Yes, I would pay up to an additional 9%
   - o Yes, I would pay more than an additional 9%

- I do not understand the question

Impares (continuación)

5. The previous text mentioned... *

   Select only one option.

   - Electric vehicles
   - Electricity generation using renewable technologies in Spain and tariffs
   - Electricity legislation

Preferencias

6. Have you thought about changing your electricity retailer in the past 12 months?

   Note: electricity retailer is the company that sends the bills. Some examples are Endesa, Holaluz, Total Energies, Iberdrola, Naturgy...

   Select only one option.

   - Yes
   - No
   - The electricity bill is not my responsibility in my household
   - I do not know

7. Do you think you could be paying a cheaper electricity bill if you changed the electricity retailer or the tariff in your current electricity retailer?

   Note: electricity retailer is the company that sends the bills. Some examples are Endesa, Holaluz, Total Energies, Iberdrola, Naturgy...

   Select only one option.

   - Yes, I think I could be paying a cheaper bill with another retailer company or another type of tariff
   - No, I do not think I could be paying a cheaper bill
   - The electricity bill is not my responsibility in my household
   - I do not know

8. Assume you have to choose a retailer for your household.

   Company 1. It offers a fixed 100 €/month tariff. Your bill will always be that amount, regardless of your consumption or the different consumption hours.

   Company 2. It offers a variable tariff. You know there is a 87.5% probability of ending up paying 80 €/month. There is also a 12.5% probability of ending up paying 160 €/month. You will not know your final debt until you receive the bill.

   Which one would you prefer?

   Select only one option.

- Company 1
- Company 2
- Indifferent
- I do not understand the question

9. Assume you have to choose a retailer for your household.

   Company 1. It offers a fixed 100 €/month tariff. Your bill will always be that amount, regardless of your consumption or the different consumption hours.

   Company 2. It offers a variable tariff. You know if you change your habits and consume electricity at specific time periods, your bill will be about 50 €/month. However, if you consume in the most expensive hours, your bill will go up to 150 €/month.

   Select only one option.

   - Company 1
   - Company 2
   - Indifferent
   - I do not understand the question

Consumer

In this section you will be asked about your current tariff and consumption. Please, try to answer the questions without looking up any information (e.g. your last bill or the internet).

10. What type of electricity tariff do you have for your household?

    Select only one option.

    - Free market
    - Regulated market or PVPC (Precio Voluntario para el Pequeño Consumidor)
    - I do not know

11. Are you currently benefiting from social subsidy ("bono social")?

    Select only one option.

    - Yes
    - No
    - I do not know if I am currently benefiting from social subsidy ("bono social")
    - I do not know what social subsidy ("bono social") is

12. If you have ever thought about changing your electricity retailer, have you identified any of the following obstacles?

You can mark more than one option

Select all options that apply

- ☐ I do not know which types of tariffs exist
- ☐ I do not know how to do research on types of tariffs
- ☐ I do not fully understand the provided information
- ☐ I do not know who I should contact to ask for a change in my electricity retailer
- ☐ The process to change retailer or tariff seems complex to me
- ☐ I think the process can take too much time
- ☐ My current option has not given me any problems and I trust the company
- ☐ The change (tariff or company) is not my responsibility (e.g. another person in my household is in charge to choose)
- ☐ I have a commitment not to change my current electricity retailer or tariff for a certain period of time
- ☐ Other reasons
- ☐ I have never thought about changing electricity retailer or tariff

Demographic data

In this section, you will be asked questions about your age, academic record…

13. Please, select your age range

Select only one option.

- o 0 – 24 years old
- o 25 – 49 years old
- o 50 – 74 years old
- o Older than 74

14. Select your gender

Select only one option.

- o Woman
- o Man
- o Other/prefer not to say

15. Choose your higher academic level, whether you have completed it or are currently studying

Select only one option.

- o Without primary studies

- Primary studies
- Secondary studies
- Baccalaureate
- Vocational/professional training
- Bachelor
- Master
- Doctorate/PhD

16. Select your current professional status

Select only one option.

- Working self employed or as an employee (including interns and apprentices)
- Studying
- Studying and working self employed or as an employee (including interns and apprentices)
- Retired
- Other

17. How many people live in your household (including yourself)?

Select only one option.

- 1
- 2
- 3
- 4 or more

18. Do you pay the electricity bill in your household?

Select only one option.

- Yes, I do
- No, someone else does
- I do not know
- The electricity bill is included in my rent

19. Does any of the following conditions apply to your household?

- Total annual income is less than 10,422.35 €

- There are three or more children (considering every person under 18 years old as a child)

- At least one person in my household receives Minimum Vital Income ("Ingreso Mínimo Vital")

Select "Yes" if any of these applies to your household, even if not all of them do

Select only one option.

- Yes
- No
- I do not know

This is the last section.

Remember to click on "Send"/"Enviar" at the end

20. The news media have exaggerated the ecological problem

Select only one option.

- 1. Strongly disagree
- 2.
- 3.
- 4.
- 5. Strongly agree

21. If humankind is going to survive at all, environmental pollution must be stopped

Select only one option.

- 1. Strongly disagree
- 2.
- 3.
- 4.
- 5. Strongly agree

22. I am worried about future children's chance of living in a clean environment

Select only one option.

- 1. Strongly disagree
- 2.
- 3.
- 4.
- 5. Strongly agree

23. We shouldn't worry about environmental problems because science and technology will solve them before very long

Select only one option.

○ 1. Strongly disagree ○ 2. ○ 3. ○ 4. ○ 5. Strongly agree

Table 10. English questionnaire. Source: author's own elaboration. (2022).

Annex IV. Statistical tests

Coding

Question number	*Question wording*	*Code*	*Alternatives*	*Code*
1	Is your birthday date odd or even?	day	Even (positive framing)	0
			Odd (negative framing)	1
2, 4	… Would you pay more to choose Company 1?	WTP	No	0
			Yes, I would pay up to an additional 3%	1
			Yes, I would pay up to an additional 6%	2
			Yes, I would pay up to an additional 9%	3
			Yes, I would pay more than an additional 9%	4
			I do not understand the question	5
6	Have you thought about changing your electricity retailer in the past 12 months?	LA1	Yes	0
			No	1
			The electricity bill is not my responsibility in my household	2
			I do not know	3
7	Do you think you could be paying a cheaper electricity bill if you changed the electricity retailer or the tariff in your current electricity retailer?	LA2	Yes, I think I could be paying a cheaper bill with another retailer company or another type of tariff	0
			No, I do not think I could be paying a cheaper bill	1
			The electricity bill is not my responsibility in my household	2
			I do not know	3
8	… Which one would you prefer?	RA	Company 1	1
			Company 2	2
			Indifferent	0
			I do not understand the question	0
			(Merged last two options due to few respondents)	
9	… Which one would you prefer?	WTC	Company 1	1
			Company 2	2
			Indifferent	0
			I do not understand the question	0
			(Merged last two options due to few respondents)	
10	What type of electricity tariff do you have for your household?	tariff	Free market	0
			Regulated market or PVPC (Precio Voluntario para el Pequeño Consumidor)	1
			I do not know	2
11	Are you currently benefiting from social subsidy ("bono social")?	bonus	Yes	0
			No	1

			I do not know if I am currently benefiting from social subsidy ("bono social")	2
			I do not know what social subsidy ("bono social") is	3
12	If you have ever thought about changing your electricity retailer, have you identified any of the following obstacles?	obs_tariff	I do not know which types of tariffs exist	1
			(Not marked)	0
12	If you have ever thought about changing your electricity retailer, have you identified any of the following obstacles?	obs_inform	I do not know how to do research on types of tariffs	1
			(Not marked)	0
12	If you have ever thought about changing your electricity retailer, have you identified any of the following obstacles?	obs_notunderstand	I do not fully understand the provided information	1
			(Not marked)	0
12	If you have ever thought about changing your electricity retailer, have you identified any of the following obstacles?	obs_contact	I do not know who I should contact to ask for a change in my electricity retailer	1
			(Not marked)	0
12	If you have ever thought about changing your electricity retailer, have you identified any of the following obstacles?	obs_complex	The process to change retailer or tariff seems complex to me	1
			(Not marked)	0
12	If you have ever thought about changing your electricity retailer, have you identified any of the following obstacles?	obs_time	I think the process can take too much time My current option has not given me any probl	1
			(Not marked)	0
12	If you have ever thought about changing your electricity retailer, have you identified any of the following obstacles?	obs_trust	My current option has not given me any problems and I trust the company	1
			(Not marked)	0
12	If you have ever thought about changing your electricity retailer, have you identified any of the following obstacles?	obs_notdep	The change (tariff or company) is not my responsibility (e.g. another person in my household is in charge to choose)	1
			(Not marked)	0
12	If you have ever thought about changing your electricity retailer, have you identified any of the following obstacles?	obs_compliance	I have a commitment not to change my current electricity retailer or tariff for a certain period of time	1
			(Not marked)	0
12	If you have ever thought about changing your electricity retailer, have you identified any of the following obstacles?	obs_other	Other reasons	1
			(Not marked)	0
12	If you have ever thought about changing your electricity retailer, have you identified any of the following obstacles?	obs_never	I have never thought about changing electricity retailer or tariff	1
			(Not marked)	0
Note that in Q12, more than one option could be chosen and it has been disaggregated into different dicotomical variables				
13	Please, select your age range	age	0 - 24 years old	0
			25 - 49 years old	1
			50 - 74 years old	2
			Older than 74	3
14	Select your gender	gender	Woman	1
			Man	0

			Other/prefer not to say	2
15	Choose your higher academic level, whether you have completed it or are currently studying	studies	Without primary studies	0
			Primary studies	1
			Secondary studies	2
			Baccalaureate	3
			Vocational/professional training	4
			Bachelor	5
			Master	6
			Doctorate/PhD	7
16	Select your current professional status	job	Working self employed or as an employee (including interns and apprentices)	0
			Studying	1
			Studying and working self employed or as an employee (including interns and apprentices)	2
			Retired	3
			Other	4
17	How many people live in your household (including yourself)?	people	1	1
			2	2
			3	3
			4 or more	4
18	Do you pay the electricity bill in your household?	owner	Yes, I do	0
			No, someone else does	1
			I do not know	2
			The electricity bill is included in my rent	2
			(Merged last two options due to few respondents)	
19	Does any of the following conditions apply to your household?	vulnerable	Yes	0
			No	1
			I do not know	2
20	The news media have exaggerated the ecological problem	scale_media	1	1
			2	2
			3	3
			4	4
			5	5
21	If mankind is going to survive at all, environmental pollution must be stopped	scale_pollution	1	1
			2	2
			3	3
			4	4
			5	5
22	I am worried about future children's chance of living in a clean environment	scale_children	1	1
			2	2
			3	3
			4	4
			5	5
23	We shouldn't worry about environmental problems because	scale_science	1	1
			2	2
			3	3

science and technology will solve them before very long	4	4
	5	5

Table 11. Coding of variables and responses. Source: author's own preparation. (2022)

Randomization check

Gender

	Woman	*Man*	*Total*
Even - Positive framing	54	56	110
Odd - Negative framing	58	64	122
Total	112	120	232

Variable	gender
Test	$\chi 2$ hypothesis test
Null hypothesis	H_o: $\mu_{positiveframing} = \mu_{negativeframing}$
Value of statistic	0.0556, df = 1 (not considering "Other/prefer not to say")
p-value	0.814
Conclusion	H_o cannot be rejected

Age

	0-24	*25-49*	*50-74*	*+75*	*Total*
Even - Positive framing	24	48	37	2	111
Odd - Negative framing	18	46	51	6	121
Total	42	94	88	8	232

Variable	age
Test	$\chi 2$ hypothesis test
Null hypothesis	H_o: $\mu_{positiveframing} = \mu_{negativeframing}$
Value of statistic	4.70, df = 3
p-value	0.195
Conclusion	H_o cannot be rejected

Level of academic studies

	N	*mean*	*median*	*SD*	*SE*
Even - Positive framing	110	5.60	6.00	0.997	0.0951
Odd - Negative framing	123	5.69	6.00	1.020	0.0917

Variable	studies
Test	T-test
Null hypothesis	H_o: $\mu_{positiveframing} = \mu_{negativeframing}$
Value of statistic	-0.688, df = 231
p-value	0.492
Conclusion	H_o cannot be rejected

Number of people in the household

	N	*mean*	*median*	*SD*	*SE*
Even - Positive framing	110	2.87	3.00	1.03	0.0985
Odd - Negative framing	123	3.12	3.00	0.99	0.0891

Variable	people
Test	T-test

Null hypothesis	H_o: $\mu_{positiveframing} = \mu_{negativeframing}$
Value of statistic	-1.88, df = 231
p-value	0.061
Conclusion	H_o cannot be rejected

Professional status

	0	*1*	*2*	*3*	*4*	*Total*
Even - Positive framing	79	5	15	7	5	111
Odd - Negative framing	77	10	9	12	15	123
Total	156	15	24	19	20	234

Variable	job
Test	$\chi 2$ hypothesis test
Null hypothesis	H_o: $\mu_{positiveframing} = \mu_{negativeframing}$
Value of statistic	8.92, df = 4
p-value	0.063
Conclusion	H_o cannot be rejected

Environmental attitude scale

scale_media:

	N	*mean*	*median*	*SD*	*SE*
Even - Positive framing	111	3.49	4.00	1.41	0.134
Odd - Negative framing	123	3.54	4.00	1.39	0.126

Variable	scale_media
Test	T-test
Null hypothesis	H_o: $\mu_{positiveframing} = \mu_{negativeframing}$
Value of statistic	-0.273, df = 232
p-value	0.785
Conclusion	H_o cannot be rejected

scale_pollution:

	N	*mean*	*median*	*SD*	*SE*
Even - Positive framing	111	4.09	5.00	1.17	0.111
Odd - Negative framing	123	4.29	5.00	0.90	0.081

Variable	scale_pollution
Test	T-test
Null hypothesis	H_o: $\mu_{positiveframing} = \mu_{negativeframing}$
Value of statistic	-1.489, df = 232
p-value	0.138
Conclusion	H_o cannot be rejected

scale_children:

	N	*mean*	*median*	*SD*	*SE*
Even - Positive framing	111	3.96	4.00	1.12	0.106
Odd - Negative framing	123	4.08	4.00	1.045	0.094

Variable	scale_children
Test	T-test
Null hypothesis	H_o: $\mu_{positiveframing} = \mu_{negativeframing}$
Value of statistic	-0.829, df = 232
p-value	0.408
Conclusion	H_o cannot be rejected

scale_science:

	N	*mean*	*median*	*SD*	*SE*
Even - Positive framing	111	4.29	5.00	1.08	0.103
Odd - Negative framing	123	4.11	4.00	1.073	0.0967

Variable	scale_science
Test	T-test
Null hypothesis	H_o: $\mu_{positiveframing} = \mu_{negativeframing}$
Value of statistic	1.237, df = 231
p-value	0.217
Conclusion	H_o cannot be rejected

Lack of priming verification

Independent samples T-test

		Statistic	*df*	*p*
LA1	Student's t	-0.0499	232	0.960
	Mann-Whitney U	6820		0.989
LA2	Student's t	1.4941	232	0.137
	Mann-Whitney U	5999		0.090
RA	Student's t	0.7236	232	0.470
	Mann-Whitney U	6469		0.428
WTC	Student's t	0.1445	232	0.885
	Mann-Whitney U	6715		0.800

Group descriptives

	Group	*N*	*mean*	*median*	*SD*	*SE*
LA1	Positive framing	111	0.946	1.00	0.807	0.0766
	Negative framing	123	0.951	1.00	0.808	0.0729
LA2	Positive framing	111	1.162	1.00	0.879	0.0835
	Negative framing	123	0.984	1.00	0.941	0.0848
RA	Positive framing	111	1.378	1.00	0.573	0.0544
	Negative framing	123	1.325	1.00	0.551	0.0497
WTC	Positive framing	111	1.604	2.00	0.544	0.0516
	Negative framing	123	1.593	2.00	0.525	0.0474

Common Method Bias – PCA

	Component											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**Uniq.**
scale_children	0.763											0.340
scale_pollution	0.758											0.305
scale_media	0.731											0.365
scale_science	0.705											0.340
WTP	0.352	0.342				0.337				0.335		0.488
age		-0.770										0.280
owner		0.665										0.402

obs_notdep	0.572		0.340					0.439
obs_notunderstand		0.716						0.372
obs_inform		0.713						0.404
obs_contact		0.515					0.324	0.423
LA2			0.750					0.307
LA1			0.690					0.341
gender			0.449			-0.388		0.370
tariff			0.327					0.421
obs_time				0.695				0.374
obs_complex		0.364		0.587				0.449
studies				0.532				0.444
obs_never				-0.526		-0.368		0.361
day					0.635			0.521
people					0.601			0.513
RA						0.802		0.290
WTC						0.673		0.382
vulnerable						0.733		0.327
bonus	0.370					0.580		0.407
job							0.750	0.299
obs_other			-0.304				0.541 -0.368	0.315
obs_trust							0.799	0.328
obs_compliance								0.775 0.368
obs_tariff		0.470						0.548 0.346

Note. 'varimax' rotation was used

Table 12. Component Loadings PCA. Source: own survey, Jamovi. (2022).

Component	*SS Loadings*	*% of Variance*	*Cumulative %*
1	2.60	8.67	8.67
2	2.14	7.14	15.81
3	2.02	6.73	22.54
4	1.86	6.21	28.75
5	1.73	5.78	34.53
6	1.53	5.09	39.62
7	1.46	4.86	44.47
8	1.41	4.71	49.18
9	1.33	4.45	53.63
10	1.31	4.38	58.01
11	1.28	4.26	62.27

Table 13. PCA Components Statistics. Source: own survey, Jamovi. (2022).

χ^2	*df*	*p*
1242	435	< .001

Table 14. Bartlett's test of sphericity. Source: own survey, Jamovi. (2022).

	MSA
Overall	0.632
age	0.582

studies	0.622
people	0.543
scale_media	0.716
scale_pollution	0.699
scale_children	0.648
scale_science	0.691
day	0.544
WTP	0.687
LA1	0.734
LA2	0.665
RA	0.450
WTC	0.594
tariff	0.688
bonus	0.702
obs_tariff	0.665
obs_inform	0.611
obs_notunderstand	0.578
obs_contact	0.630
obs_complex	0.630
obs_time	0.597
obs_trust	0.496
obs_notdep	0.638
obs_compliance	0.507
obs_other	0.596
obs_never	0.535
gender	0.587
job	0.482
owner	0.718
vulnerable	0.532

Table 15. KMO measure of sample adequacy. Source: own survey, Jamovi. (2022).

Correlation matrices

Correlation with demographic variables

		WTP	***LA1***	***LA2***	***RA***	***WTC***	***age***	***studies***	***gender***	***people***	***job***
WTP	Spearman's rho	—									
	p-value	—									
LA1	Spearman's rho	0.040	—								
	p-value	0.542	—								
LA2	Spearman's rho	-0.056	0.434***	—							
	p-value	0.391	< .001	—							
RA	Spearman's rho	-0.025	-0.021	-0.056	—						
	p-value	0.708	0.753	0.395	—						
WTC	Spearman's rho	0.124	-0.161*	-0.115	0.276***	—					

	p-value	0.058	0.014	0.079	< .001	—					
age	Spearman's rho	-0.213**	-0.201**	-0.124	-0.082	0.022	—				
	p-value	0.001	0.002	0.060	0.216	0.738	—				
studies	Spearman's rho	-0.011	-0.130*	-0.107	-0.001	0.133*	-0.033	—			
	p-value	0.871	0.047	0.103	0.991	0.043	0.614	—			
gender	Spearman's rho	0.124	0.090	0.135*	-0.075	0.015	0.075	-0.221***	—		
	p-value	0.059	0.172	0.039	0.253	0.820	0.257	< .001	—		
people	Spearman's rho	0.148*	0.093	0.045	-0.004	0.021	-0.045	0.014	0.088	—	
	p-value	0.024	0.157	0.495	0.948	0.749	0.501	0.829	0.181	—	
job	Spearman's rho	0.082	0.199**	0.120	-0.067	-0.190**	0.090	-0.220***	-0.001	-0.006	—
	p-value	0.213	0.002	0.067	0.305	0.004	0.173	< .001	0.984	0.922	—

*Note. * p < .05, ** p < .01, *** p < .001*

Table 16. Correlation with age, studies, gender, people and job. Source: own survey, Jamovi. (2022).

Correlation with type of consumer variables

		WTP	***LA1***	***LA2***	***RA***	***WTC***	***owner***	***vulnerable***	***bonus***	***tariff***
WTP	Spearman's rho	—								
	p-value	—								
LA1	Spearman's rho	0.040	—							
	p-value	0.542	—							
LA2	Spearman's rho	-0.056	0.434***	—						
	p-value	0.391	< .001	—						
RA	Spearman's rho	-0.025	-0.021	-0.056	—					
	p-value	0.708	0.753	0.395	—					
WTC	Spearman's rho	0.124	-0.161	-0.115	0.276***	—				
	p-value	0.058	0.014	0.079	< .001	—				
owner	Spearman's rho	0.217***	0.297***	0.131*	0.006	0.003	—			
	p-value	< .001	< .001	0.045	0.930	0.965	—			
vulnerable	Spearman's rho	-0.025	0.071	0.071	0.092	0.095	0.060	—		
	p-value	0.699	0.281	0.282	0.163	0.151	0.366	—		
bonus	Spearman's rho	0.193**	0.251***	0.210**	-0.056	-0.084	0.204**	0.220***	—	
	p-value	0.003	< .001	0.001	0.397	0.203	0.002	< .001	—	
tariff	Spearman's rho	0.016	0.312***	0.178**	-0.118	-0.084	0.293**	0.073	0.204**	—
	p-value	0.803	< .001	0.006	0.073	0.199	< .001	0.266	0.002	—

*Note. * p < .05, ** p < .01, *** p < .001*

Table 17. Correlation with owner, vulnerable, bonus and tariff. Source: own survey, Jamovi. (2022).

Correlation with environmental attitude scale variables

		WTP	LA1	LA2	RA	WTC	scale_media	scale_pollution	scale_children	scale_science
WTP	Spearman's rho	—								
	p-value	—								
LA1	Spearman's rho	0.040	—							
	p-value	0.542	—							
LA2	Spearman's rho	-0.056	0.434***	—						
	p-value	0.391	< .001	—						
RA	Spearman's rho	-0.025	-0.021	-0.056	—					
	p-value	0.708	0.753	0.395	—					
WTC	Spearman's rho	0.124	-0.161*	-0.115	0.276***	—				
	p-value	0.058	0.014	0.079	< .001	—				
scale_media	Spearman's rho	0.247***	-0.061	-0.052	0.080	0.169**	—			
	p-value	< .001	0.353	0.433	0.223	0.010	—			
scale_pollution	Spearman's rho	0.271***	-0.078	-0.135*	-0.102	0.168*	0.490***	—		
	p-value	< .001	0.233	0.039	0.120	0.010	< .001	—		
scale_children	Spearman's rho	0.221***	-0.089	-0.102	-0.080	0.148*	0.443***	0.605***	—	
	p-value	< .001	0.174	0.121	0.221	0.024	< .001	< .001	—	
scale_science	Spearman's rho	0.264***	-0.151*	-0.109	-0.031	0.173**	0.589***	0.455***	0.376***	—
	p-value	< .001	0.021	0.097	0.633	0.008	< .001	< .001	< .001	—

*Note. * p < .05, ** p < .01, *** p < .001*

Table 18. Correlation with scale_media, scale_pollution, scale_children and scale_science. Source: own survey, Jamovi. (2022).

One-Way ANOVA tests

One-Way ANOVA "age"

	F	df1	df2	p
WTP	2.42	3	32.2	0.084
LA1	5.34	3	31.6	0.004
LA2	3.93	3	30.7	0.017
RA	4.53	3	34.2	0.009
WTC	1.46	3	31.0	0.244

Table 19. One-Way ANOVA (Welsch's), grouping variable: "age". Source: own survey, Jamovi. (2022).

	age	N	Mean	SD	SE
WTP	0-24	42	1.333	1.223	0.1887
	25-49	94	1.234	1.307	0.1348
	50-74	88	0.807	1.249	0.1331
	75	8	0.875	1.126	0.3981
LA1	0-24	42	1.452	0.916	0.1413

	25-49	94	0.830	0.812	0.0837
	50-74	88	0.852	0.670	0.0714
	75	8	0.750	0.707	0.2500
LA2	0-24	42	1.476	0.917	0.1415
	25-49	94	0.894	0.848	0.0875
	50-74	88	1.045	0.883	0.0941
	75	8	1.125	1.246	0.4407
RA	0-24	42	1.381	0.582	0.0899
	25-49	94	1.372	0.548	0.0566
	50-74	88	1.341	0.565	0.0602
	75	8	0.875	0.354	0.1250
WTC	0-24	42	1.500	0.506	0.0781
	25-49	94	1.649	0.543	0.0560
	50-74	88	1.625	0.510	0.0544
	75	8	1.250	0.707	0.2500

Table 20. Group descriptives for One-Way ANOVA, grouping variable: "age". Source: own survey, Jamovi. (2022).

One-Way ANOVA "gender"

	F	*df1*	*df2*	*p*
WTP	11.206	1	226	0.291
LA1	22.847	1	230	0.132
LA2	45.216	1	230	0.035
RA	13.170	1	229	0.252
WTC	0.0232	1	229	0.879

Table 21. One-Way ANOVA (Welsch's), grouping variable: "gender". Source: own survey, Jamovi. (2022).

	gender	*N*	*Mean*	*SD*	*SE*
WTP	Woman	112	0.964	1.315	0.1242
	Man	120	1.142	1.232	0.1125
LA1	Woman	112	0.866	0.777	0.0734
	Man	120	1.025	0.825	0.0753
LA2	Woman	112	0.938	0.883	0.0834
	Man	120	1.192	0.938	0.0856
RA	Woman	112	1.393	0.559	0.0528
	Man	120	1.308	0.562	0.0513
WTC	Woman	112	1.589	0.529	0.0500
	Man	120	1.600	0.541	0.0494

Table 22. Group descriptives for One-Way ANOVA, grouping variable: "tariff". Source: own survey, Jamovi. (2022).

One-Way ANOVA "tariff"

	F	*df1*	*df2*	*p*
WTP	0.0332	2	152	0.967
LA1	124.080	2	152	< .001
LA2	37.677	2	150	0.025
RA	19.391	2	150	0.147
WTC	26.213	2	148	0.076

Table 23. One-Way ANOVA (Welsch's), grouping variable: "tariff". Source: own survey, Jamovi. (2022).

	tariff	N	Mean	SD	SE
WTP	Free	80	1.050	1.231	0.1377
	Regulated	81	1.049	1.303	0.1448
	Notknow	72	1.097	1.313	0.1547
LA1	Free	80	0.688	0.739	0.0827
	Regulated	81	0.877	0.765	0.0850
	Notknow	72	1.306	0.799	0.0941
LA2	Free	80	0.925	0.883	0.0987
	Regulated	81	0.975	0.836	0.0929
	Notknow	72	1.319	0.990	0.1167
RA	Free	80	1.450	0.549	0.0614
	Regulated	81	1.321	0.520	0.0578
	Notknow	72	1.278	0.610	0.0719
WTC	Free	80	1.625	0.487	0.0545
	Regulated	81	1.679	0.470	0.0522
	Notknow	72	1.472	0.627	0.0739

Table 24. Group descriptives for One-Way ANOVA, grouping variable: "tariff". Source: own survey, Jamovi. (2022).

One-Way ANOVA "bonus"

	F	df1	df2	p
WTP	1.78	3	45.3	0.165
LA1	8.58	3	45.8	< .001
LA2	5.09	3	46.8	0.004
RA	1.58	3	46.6	0.207
WTC	1.54	3	44.8	0.217

Table 25. One-Way ANOVA (Welsch's), grouping variable: "bonus". Source: own survey, Jamovi. (2022).

	bonus	N	Mean	SD	SE
WTP	0	25	0.760	1.422	0.2845
	1	162	1.019	1.233	0.0969
	2	23	1.217	1.278	0.2664
	3	23	1.609	1.340	0.2793
LA1	0	25	0.880	0.726	0.1451
	1	162	0.802	0.746	0.0586
	2	23	1.522	0.730	0.1523
	3	23	1.435	0.945	0.1971
LA2	0	25	1.000	0.866	0.1732
	1	162	0.957	0.894	0.0702
	2	23	1.565	0.788	0.1643
	3	23	1.478	0.994	0.2073
RA	0	25	1.280	0.542	0.1083
	1	162	1.389	0.560	0.0440
	2	23	1.348	0.573	0.1194
	3	23	1.130	0.548	0.1143
WTC	0	25	1.560	0.583	0.1166
	1	162	1.648	0.504	0.0396
	2	23	1.435	0.507	0.1057
	3	23	1.478	0.665	0.1387

Table 26. Group descriptives for One-Way ANOVA, grouping variable: "bonus". Source: own survey, Jamovi. (2022).

One-Way ANOVA "vulnerable"

	F	*df1*	*df2*	*p*
WTP	0.0215	2	9.50	0.979
LA1	0.8187	2	9.23	0.471
LA2	14.369	2	9.10	0.287
RA	25.463	2	9.50	0.130
WTC	21.724	2	9.14	0.169

Table 27. One-Way ANOVA (Welsch's), grouping variable: "vulnerable". Source: own survey, Jamovi. (2022).

	vulnerable	*N*	*Mean*	*SD*	*SE*
WTP	0	18	1.111	1.132	0.2668
	1	209	1.077	1.299	0.0898
	2	5	1.000	1.000	0.4472
LA1	0	18	0.833	0.707	0.1667
	1	209	0.952	0.813	0.0562
	2	5	1.400	0.894	0.4000
LA2	0	18	1.000	0.840	0.1980
	1	209	1.043	0.900	0.0623
	2	5	2.000	1.225	0.5477
RA	0	18	1.111	0.471	0.1111
	1	209	1.373	0.567	0.0392
	2	5	1.200	0.447	0.2000
WTC	0	18	1.333	0.594	0.1400
	1	209	1.622	0.524	0.0363
	2	5	1.400	0.548	0.2449

Table 28. Group descriptives for One-Way ANOVA, grouping variable: "vulnerable". Source: own survey, Jamovi. (2022).

Obstacles – PCA

	Component				
	1	**2**	**3**	**4**	**Uniqueness**
obs_tariff		0.717			0.466
obs_inform		0.655			0.484
obs_notunderstand		0.654			0.438
obs_contact	0.549				0.538
obs_complex	0.688				0.484
obs_time	0.743				0.430
obs_trust			0.609		0.609
obs_notdep			0.577	0.502	0.412
obs_compliance				0.522	0.558
obs_other		-0.321	-0.655	0.318	0.367
obs_never	-0.368			-0.702	0.371

Note. 'varimax' rotation was used

Table 29. Component Loadings PCA. Source: own survey, Jamovi. (2022).

Component	*SS Loadings*	*% of Variance*	*Cumulative %*
1	1.70	15.4	15.4
2	1.68	15.2	30.6
3	1.28	11.7	42.3
4	1.19	10.8	53.1

Table 30. PCA Components Statistics. Source: own survey, Jamovi. (2022).

χ²	*df*	*p*
240	55	< .001

Table 31. Bartlett's test of sphericity. Source: own survey, Jamovi. (2022).

	MSA
Overall	0.562
obs_tariff	0.658
obs_inform	0.640
obs_notunderstand	0.594
obs_contact	0.707
obs_complex	0.711
obs_time	0.600
obs_trust	0.318
obs_notdep	0.298
obs_compliance	0.326
obs_other	0.413
obs_never	0.425

Table 32. KMO measure of sample adequacy. Source: own survey, Jamovi. (2022).

Loss aversion and type of tariff

Hypothesis testing for differences in Q10 according to answer in Q7

	LA2				
tariff	**0**	**1**	**2**	**3**	**Total**
Free	27	39	7	7	80
Regulated	23	43	9	6	81
Notknow	20	16	29	7	72
Total	70	98	45	20	233

Table 33. Contingency table for groups in Q10 and responses in Q7. Source: own survey, Jamovi. (2022).

	Value	*df*	*p*
χ²	34.6	6	< .001
N	233		

Table 34. χ2 test for differences in Q7 depending on Q10. Source: own survey, Jamovi. (2022).

Fixed vs variable tariff

	WTC		
RA	**C1fixed**	**C2variable**	**Total**
C1fixed	63	67	130

C2variable	17	73	90
Total	80	140	220

"Indifferent" and "I do not understand the question" responses excluded to insubstantial number of respondents choosing them

Table 35. Paired Samples Contingency Table for RA and WTC. Source: own survey, Jamovi. (2022).

	Value	***df***	***p***
χ^2	29.8	1	< .001
N	220		

Table 36. McNemar test for Paired Samples Contigency Table for RA and WTC. Source: own survey, Jamovi. (2022).