



**HAL**  
open science

**Consumer awareness of renewable energy and willingness-to-pay for energy transition in France: the less you know, the less you pay? Evidence from a discrete choice experiment**

Olivier Beaumais, Romain Crastes Dit Sourd, Dimitri Laroutis, Patrice Lepelletier, Salima Taibi-Hassani

► **To cite this version:**

Olivier Beaumais, Romain Crastes Dit Sourd, Dimitri Laroutis, Patrice Lepelletier, Salima Taibi-Hassani. Consumer awareness of renewable energy and willingness-to-pay for energy transition in France: the less you know, the less you pay? Evidence from a discrete choice experiment. 9th FAERE ANNUAL CONFERENCE, UNIVERSITY ROUEN NORMANDY, Sep 2022, ROUEN, France. hal-04435149

**HAL Id: hal-04435149**

**<https://normandie-univ.hal.science/hal-04435149>**

Submitted on 2 May 2024

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

**Consumer awareness of renewable energy and willingness-to-pay for energy transition in France:  
the less you know, the less you pay? Evidence from a discrete choice experiment**

Olivier Beaumais<sup>a</sup>, Romain Crastes dit Sourd<sup>b</sup>, Dimitri Laroutis<sup>c</sup>, Patrice Lepelletier<sup>d</sup>, Salima Taïbi<sup>d</sup>  
Hassani

**Abstract:** We conduct a discrete choice experiment in France to explore how consumers' awareness of the energy transition and three renewable energy sources to produce "green" electricity shapes preferences and willingness-to-pay for green electricity. To address the issue of measurement error associated with respondents' awareness as a predictor of willingness-to-pay for green electricity, we estimate a hybrid choice model. Results show that respondents are willing to pay for green electricity and that the WTP for each of the three green electricity sources considered is indeed significantly and positively associated with awareness of energy transition and specific awareness regarding each of the green electricity sources.

**Keywords:** Green electricity portfolio, consumer awareness, willingness-to-pay, discrete choice experiment, hybrid choice model

**Acknowledgement:** This article is part of the DETECTE (Développement Economique & Territorial, Economie Circulaire et Transition Energétique) research project funded under the PSDR IV program.

<sup>a</sup> LERN, UR 4702, University of Rouen Normandy and LISA UMR CNRS 6240, University of Corsica

<sup>b</sup> Centre for Decision Research, Management Division, Leeds University Business School and Choice Modelling Centre, University of Leeds

<sup>c</sup> Centre d'Etude sur le Risk Management (CERM), ESC Amiens

<sup>d</sup> InTerACT UP 2018.C102 research unit, UniLaSalle

## 1. Introduction

In the third instalment of its Sixth Assessment Report (AR6), the Intergovernmental Panel on Climate Change (IPCC) recalls that limiting global warming requires substantial reduction in fossil fuel use, particularly through the widespread use of green electricity (IPCC, 2022). Green electricity, *i.e.* electricity produced from renewable sources, includes solar photovoltaic, wind power and electricity generated from biogas produced from anaerobic digestion (methanization).

Of course, as for other renewable energies (Bourcet, 2020), widespread deployment of green electricity cannot be achieved without identifying what the IPCC refers to as enabling conditions, which are defined as “conditions that enhance the feasibility of adaptation and mitigation options. Enabling conditions include finance, technological innovation, strengthening policy instruments, institutional capacity, multi-level governance and changes in human behaviour and lifestyles” (IPCC, 2022).

These enabling conditions are not mutually exclusive, but on the contrary closely intertwined. For example, Herbes *et al.* (2020) show that one of the conditions for voluntary green electricity markets to succeed in replacing state-led support for the expansion of green electricity is that product strategies of green electricity marketers actually match consumer preferences for green electricity that, they find, was not the case in France at the time they did their study.

Elicitation of consumer preferences for green electricity is thus essential to clearly identify effective ways to change human behaviour and lifestyles. This can be done by exploring willingness-to-pay for green electricity (Cardella *et al.*, 2022).

The literature on willingness-to-pay for green electricity is vast (Sundt and Rehdanz, 2015). Recent contributions focus on specific sources of green electricity, solar (Mamkhezri *et al.*, 2020) or on factors, such as equity motives, that may influence willingness-to-pay (Andor *et al.*, 2018).

Amongst these factors, whether citizens know about renewable energy (RE) sources and what each source entails (in terms of the way it is produced and how it reduces greenhouse gases emission) has only received little attention from researchers. Findings are mixed. In their meta-analysis of the literature of consumers’ willingness-to-pay for green electricity, Sundt and Rehdanz (2015) report only three studies that consider knowledge of RE sources as a factor influencing willingness-to-pay for green electricity. Bollino (2009) finds that general knowledge of RE sources in Italy is significant and negatively associated with WTP for green electricity. The author suggests that this unexpected result (a positive relationship would have been assumed) is driven by the fact that respondents’ knowledge is actually not accurate at all: indeed, almost 80% of respondents express an overall knowledge of renewable energy, but additional questions on specific renewable energy sources show that this knowledge is in fact low. Kim *et al.* (2013) find no significant association of the (limited) knowledge of the ratio of renewable electricity to total power generation with WTP for green electricity in South Korea. On the contrary, Zografakis *et al.* (2010) report that WTP for RE sources is significant and positively associated with knowledge of solar and biomasses power in Crete.

We argue that what is called knowledge of renewable energies in the literature is mainly a matter of perception and should more properly be called awareness of renewable energies, as defined, for example, by Wall *et al.* (2021): “Awareness refers to the level of consumers’ knowledge and perception of the facts regarding renewable energy technologies.” We further argue that a rigorous assessment

of the relationship between knowledge and WTP for green electricity requires an appropriate econometric strategy, given that perception variables are known to be prone to measurement error (Hess and Stathopoulos, 2013).

We propose to explore how WTP for green electricity is associated with consumers' awareness of three RE sources, solar, wind and biogas using data from a discrete choice experiment conducted in France in summer 2019. Respondents were asked to evaluate different green electricity scenarios defined in terms of energy mixes featuring solar, wind and biogas based power, the impact on the kWh price being the monetary attributes in the scenarios. Specific questions were designed to assess respondents' awareness of energy transition and of the three RE sources. To address the issue of measurement error of respondents' awareness as a predictor of WTP for green electricity, we estimate a hybrid choice model, which is a common approach to address the measurement error issue in a wide variety of empirical contexts (Akinwehinmi *et al.*, 2021, Budziński and Czajkowski, 2022). It is worth noting that hybrid choice models have rarely been used to analyse data from discrete choice experiments focused on RE, Motz (2021) being an exception.

Our contributions to the literature are mainly two-fold. First, and surprisingly, little is known about French citizens' preferences regarding RE. Our survey aims to fill this gap and provide new guidance for policy makers involved in the promotion of renewable energy. Second, using an appropriate econometric framework, our results show that respondents are willing to pay for green electricity and that the WTP for each of the three green electricity sources considered is indeed significantly and positively associated with awareness of energy transition and specific awareness of each of the green electricity sources.

The rest of the paper is organized as follows. Section 2 presents the background of the study and the related literature. Section 3 is devoted to the survey design and provides some descriptive statistics of the data collected. Section 4 and 5 refer respectively to the modelling work and the results. Further discussion of the policy implications of the results is provided in Section 6.

## **2. Background and related literature**

### *Background*

In France, energy produced from renewable energy sources is promoted both by state aid (tax credits, zero-interest loans, reduced VAT, subsidies, etc.) for the installation of specific infrastructures (photovoltaic, wind power, etc.) and by feed-in-tariff (FIT) system. Until 2015, the French law of February 10, 2000 required distribution companies to purchase, under contracts of 12 to 20 years and at a price well above the market price, the electricity produced from renewable energy sources. However, as the regulatory commission considered that this purchase mechanism could amount to state aid in the eyes of European institutions (and therefore contrary to the opening up of the markets), the additional remuneration ("*complément de rémunération*") system was introduced in 2016. Producers have the choice between selling their electricity directly on the wholesale markets or going through a renewable production aggregator which will market their energy. In brief, renewable energy producers receive a premium fee if market price is below a reference price fixed by the French government.

	1990	1995	2000	2005	2010	2015	2016	2017	2018	Since 2000
<b>Gross Electricity Generation, by Fuel [TWh]</b>	<b>420,75</b>	<b>494,27</b>	<b>539,95</b>	<b>576,06</b>	<b>569,15</b>	<b>578,82</b>	<b>563,62</b>	<b>561,21</b>	<b>581,28</b>	<b>+7,65%</b>
<b>Renewables and biofuels</b>	59,33	78,53	74,17	61,18	83,01	96,79	103,86	97,75	118,70	+60,04%
<b>Hydro</b>	57,42	76,19	71,13	56,33	67,53	60,51	65,69	55,13	70,59	-0,75%
<b>Wind</b>	0,00	0,00	0,05	0,96	9,94	21,42	21,38	24,61	28,60	+57200%
<b>Methanization</b>	0,07	0,08	0,31	0,48	1,01	1,83	1,99	2,12	2,36	+761%
<b>Solar</b>	0,00	0,00	0,01	0,01	0,62	7,75	8,66	9,58	10,57	+105700%
<b>Other</b>	1,84	2,25	2,68	3,39	3,92	5,27	6,14	6,29	6,58	+245%

Table 1: Renewable energy production in France. Source: Eurostat

Since the introduction of these incentives in the 2000s, renewable energy production capacity has increased significantly (Table 1). Wind and photovoltaic power have experienced the most significant growth. For example, wind power increased from 0.96TWh to 28.60 TWh in 2018 and photovoltaic power from 0.01 to 10.57 TWh.

In 2018, total green energy production capacity reached 118.7 TWh, or 20.35% of French electricity production. In 2019, the wind and solar power capacity increased by 9% and 10.4% respectively. According to the electricity barometer observatory, the wind and solar sectors currently represent an installed capacity equivalent to that of hydropower with a share of 48% of the full renewable mix. In order to reach France's objective of 32% of green energy in the final gross energy consumption in 2030, it will be necessary to increase investments and multiply the number of facilities, which will automatically lead to an increase in the cost of electricity production.

	European Union - 28 countries (2013-2020)	Belgium	Denmark	Germany	Spain	France	Italy	Luxembourg	Finland	Sweden	United Kingdom
<b>2008</b>	0,1583	0,1972	0,2635	0,2148	0,1366	0,1213	0,2031	0,1645	0,1223	0,1698	0,1458
<b>2009</b>	0,164	0,1916	0,2699	0,2282	0,1577	0,1206	0,2098	0,1882	0,1296	0,1602	0,1466
<b>2010</b>	0,1678	0,1959	0,267	0,2375	0,1728	0,1283	0,1965	0,1726	0,1325	0,1839	0,1386
<b>2011</b>	0,18	0,2136	0,2908	0,2528	0,1981	0,1383	0,1987	0,1678	0,154	0,2092	0,1433
<b>2012</b>	0,1884	0,2327	0,2997	0,2595	0,219	0,1392	0,2132	0,1696	0,1549	0,2027	0,1682
<b>2013</b>	0,2001	0,2173	0,3	0,2919	0,2228	0,1524	0,2292	0,1665	0,1578	0,2101	0,1741
<b>2014</b>	0,2039	0,2097	0,3042	0,2981	0,2165	0,1585	0,2446	0,1738	0,1563	0,1967	0,1918
<b>2015</b>	0,2088	0,2126	0,3068	0,2951	0,2309	0,1676	0,245	0,1767	0,1552	0,1851	0,2125
<b>2016</b>	0,2037	0,2544	0,3088	0,2969	0,2185	0,1685	0,2342	0,1698	0,1541	0,1894	0,1951
<b>2017</b>	0,203	0,2857	0,3049	0,3048	0,2296	0,1704	0,2132	0,1615	0,1581	0,1936	0,1766
<b>2018</b>	0,2058	0,2824	0,3126	0,2987	0,2383	0,1748	0,2067	0,1671	0,1612	0,1891	0,1887
<b>2019</b>	0,2154	0,2839	0,2984	0,3088	0,2403	0,1778	0,2301	0,1798	0,1734	0,2058	0,2122

Table 2: Average electricity prices (household consumers, € per kWh, including taxes and levies).

Source: Eurostat

Currently, as shown in Table 2, France enjoys one of the lowest electricity price in the European Union. With the increase of the share of renewable energy in the energy mix, this price will mechanically increase, following the example of Germany, which is aiming for 50% renewable energy in 2030 (Andor *et al.*, 2017) and which experiences some of the highest electricity production costs in the EU. The electricity price is thus growing steadily: +36% on average in the EU between 2008 and 2019, +46% in France.

According to the French Court of Audit (Cour des Comptes, 2018), the projected amount of public subsidies to support green electricity would be €7.5 billion annually on average until 2023. The Institute

for Climate Economics (I4CE, 2020) even considers that meeting the ambitious French targets for the country's low-carbon strategy will require annual funding of about €19 billion for the 2024-2028 period to support green electricity investment. The dynamics are also very strong on the support for biogas: the public subsidies amounted to €20.9 M in 2016, and should reach €326 M in 2023. These large investments and the constantly increasing production costs will automatically lead to an additional cost for households and an increase in their electricity bill. The discounted production cost of onshore wind power is between €50 and €71/MWh, hydroelectric power between €32 and €149/MWh, and photovoltaic power between €57 and €229/MWh, compared to the production cost of nuclear power, which is estimated at around €33/MWh.

The public subsidies for RE will represent about 1.8 c€/kWh consumed in 2023, while they amounted to about 1.0 c€/kWh in 2016. For an average French household (whose consumption is estimated at about 4500 kWh) the additional cost would be about 81€/year. These amounts appear very low, particularly compared to Germany, whose charges were estimated at 4.5 c€ per kWh consumed, *i.e.* an additional cost of around 500 euros/year per household (Andor *et al.*, 2017).

As Andor *et al.* (2017) point out, measuring the additional costs is not all there is to consider. It is also necessary to integrate a social perspective by taking into account the benefits of RE as accurately as possible. Studies aiming to integrate this social perspective and the perception of individuals on the policies implemented have multiplied in recent years. Strigka *et al.* (2014) in a synthesis of the use of the contingent valuation method summarize the situation as follows: conventional energy sources, and particularly coal, are characterized by very high carbon dioxide emissions per kWh, low price and high availability (compared to more environmentally friendly energy sources). On the other side, green energy sources have low social costs (environmental friendliness) but are more expensive which hinders their potential for development. Soon and Ahmad (2015) point out that renewable energy sources are set to become the main source of energy in the future despite higher costs and the need for specific policy mechanisms (Zoric and Hrovatin, 2012). Kim *et al.* (2013) also questioned the economic viability of RE production. This observation leads Akcura (2015) to consider the targets set by governments as unrealistic without regulatory support aimed at the adoption of green electricity by households.

#### *Related literature*

Green electricity has received a lot of attention in recent years (Zoric and Horvatin, 2012) particularly in assessing household WTP. However, the current literature has failed to reach a consensus on how much households would be willing to pay (Soon and Ahmad, 2015). One explanation may be the diversity of countries and cultures. According to Soon and Ahmad (2015), three types of WTP studies have been conducted:

- The first group of studies explores WTP for "generic" green power. For example, Kim *et al.* (2013) study the WTP of 495 consumers in Korea through the implementation of a premium for green electricity. Green electricity is then perceived as a differentiated good from traditional electricity. The WTP is USD 1.26/month (+2.8% on the bill), *i.e.* a potential benefit of USD 209 million. This then only covers 43.5% of the total government budget assigned to the promotion of renewable energy. Akcura (2015), for his part, looks at the impact of implementing a mandatory contribution for the development of renewable resources in the

United Kingdom. He finds that a mandatory tax would be preferable because of greater certainty about the amounts collected.

- The second group of studies uses DCE to analyse WTP for increased share of RE in the energy mix. Solino *et al.* (2012) analyse consumer preferences to shift the traditional energy policy in Spain towards a policy oriented to the use of biomass. They estimate WTP for different attributes: reduction of the greenhouse effect, decrease of pressure on non-renewable resources, decrease of the risk of summer fires, new jobs in rural areas, increase of the price of the electricity bill. Gracia *et al.* (2012), on the other hand, suggest that a large portion of the population is not willing to pay for an energy mix. Solar energy does not pose an adoption problem unlike wind and biomass. Their adoption would require a reduction in price.
- The third group of studies relies on the contingent valuation method to evaluate the WTP for renewable energy sources, with a focus on their environmental impact. Zoric and Hrovatin (2012) investigate the WTP of households in Slovenia to expand the use of green energy. The explanatory variables for WTP are age in a negative way. The rest of the significant variables, *i.e.*, household income, education level, and environmental sensitivity, reveal a positive influence. Cheng *et al.* (2017) focus on Hong Kong residents for a decarbonisation of the city. Paravantis *et al.* (2018) focus on western Greece and the social acceptance of renewable energy projects. The typical green consumer appears to be young, educated, wealthier willing to pay for the realization of future projects but not during their lifetime. Xie and Zhao's (2018) study focuses on green electricity development in Tianjin, China. They highlight the importance of knowledge of renewable energy, belief in government, education, history in terms of respiratory disease, and income in revealing WTP.

Kim *et al.* (2013) highlight the diversity of the approaches seeking to measure WTP for green energy development. Some consider green energy as a homogeneous good, while others are more interested in analysing the specificities of each type of electricity generated from renewable sources. In an effort to find patterns in WTP for RE, Soon and Ahmad (2015) conduct a meta-analysis. Through the analysis of 30 studies on the subject they obtain a WTP estimate of USD 7.16. For them, urban and North Americans reveal a higher WTP than people living in a rural environment and being part of Asia.

The information provided to individuals appears essential in the acceptability of renewable energy projects. Soland *et al.* (2013), concerning Switzerland, seek to understand the importance of the information provided in the decision making of individuals. The quality of the information provided, both on the objectivity and veracity of the information, and its adequacy with the level of knowledge of the citizen play an important role when revealing the WTP. These authors demonstrate the indirect but significant effect of receiving information of a high standard on local acceptance. Citizens who have been directly informed by people involved in the planning process show a higher level of perceived benefits of such projects and a lower level of perceived costs. Soland *et al.* (2013) also advise providing information to citizens on a regular basis in order to reduce concerns and increase their trust in planners. They argue, unlike Upreti and Van de Horst (2004) or Zoellner *et al.* (2008), that the timeliness of information provision is not essential, but the quality of the information provided is. Motz (2021) even speaks of energy illiteracy in his study of Swiss citizens. He advocates the implementation of energy literacy measures in order to create or maintain a consensus and achieve the desired energy policy objectives.

According to Sundt and Rehdanz (2015), studies examining the impact of renewable energy knowledge on WTP show mixed results. In their green energy meta-analysis, they report that RE knowledge actually increases WTP for RE. Bae and Rishi (2018) highlight the importance of attitudinal factors in decision making. Through their survey of 600 Korean citizens, they demonstrate the importance of environmental awareness, pro-environmental behaviour or attitudes, altruism, and renewable energy information on WTP. Kim *et al.* (2018) also highlight the importance of education level and general literacy. This finding is also confirmed by Bakkensen and Schuler (2020) in their work on Vietnam. Their survey of 14,000 Vietnamese emphasizes that education and knowledge of environmental issues are the only factors affecting WTP for renewable energy. Regarding the United States, Conte and Jacobson (2016) had already pointed out that green electricity programs experience higher levels of participation especially in areas with educated populations. Most recently, Knapp *et al.* (2020) find that participation rates in green pricing programs are higher in regions where consumers are more sensitive to the environmental impacts of energy.

Bakkensen and Schuler (2020) also emphasize the importance of experiential knowledge. Individuals who have experienced poor air quality are less likely to support polluting energy production sources such as coal. However, these individuals will not necessarily have a higher willingness to pay to further support renewable energy. Longo *et al.* (2018), in a study of the experience of long or short power outages in the home or workplace, indicate a positive influence of this variable on the ability to shape consumers' preferences for each energy source. Finally, Bae *et al.* (2018) show that distance to green energy infrastructure affects individuals' participation in the green pricing program. They show that residents living near a green power plant show a preference for fuel cells, followed by solar and wind power.

### **3. Survey design and descriptive statistics**

#### *Survey design*

The survey design followed closely the recommendations of Johnston *et al.* (2017) for stated preference studies. For example (recommendation 1), the status quo was clearly presented to the respondent as the current portfolio of renewable sources of electricity at the time the survey was administrated (see Table 1 below). In addition (recommendation 2), quantitative pretesting was conducted with a sample of approximately 50 individuals, etc. Beyond these general recommendations, we have also relied on specific recommendations from the literature on willingness to pay for renewable energy. For example, Sundt and Rehdanz (2015), based on a meta-analysis of the literature on WTP for green electricity, make the following recommendation: "We recommend researchers either to directly use the unit kilowatt-hour in stated preference WTP questions or to convert values per household per month by using information about household-size and electricity consumption. (p. 7)." Also, "significance of the dummy variables, describing the explanatory variables of study's WTP estimation, suggests that controlling for knowledge about renewables, household characteristics, income and education significantly influences WTP estimates. Ignoring these attributes in future WTP estimations might result in biased coefficients."

The questionnaire consists of four sections. The first section deals only with the respondent's precise location: address, duration of residence, previous location. The second section focuses on the respondent's knowledge of the energy transition and renewable energy. The respondent was asked if

he/she had ever heard of energy transition, and then a precise definition of energy transition, taken from French law, was provided.

Next, respondents were asked if they were familiar with each of the following renewable energies: wind, photovoltaic and methanization. Each of these three renewable energies was then the subject of a detailed presentation (one-page flyer) describing their advantages and disadvantages in a neutral way. The objective of this presentation was to ensure that respondents were at the same level of information before the actual choice experiment.

The third section of the questionnaire was the choice experiment. The fourth section was dedicated to the collection of socio-demographic variables.

The alternatives were presented as energy transition scenarios based on four attributes. The first three attributes correspond respectively to the share of wind, photovoltaic and methanization in the electricity consumed. This share varies according to the renewable energy (see Table 3), to provide realistic variations compared to the status quo.

Attribute	Attribute level*	Definition
Wind	<b>4.6%</b> , 6%, 8%, 10%, 12%	Share of wind power in consumed electricity
Solar	<b>0.5%</b> , 2%, 6%, 8%, 10%	Share of photovoltaic (rooftop) in consumed electricity
Metha	<b>1.1%</b> , 2%, 6%, 8%, 10%	Share of methanization in consumed electricity
Price	<b>0</b> , €c1, €c2, €c4, €c6	Change in price per kWh
Note: *Levels in bold are status quo levels		

Table 3: Attributes, levels and definition

Consequently, an energy transition scenario corresponds to a green electricity portfolio by 2030. The combination of attributes and their levels according to an efficient design allows to generate 12 scenarios with four alternatives each (including the status quo) using Ngene (ChoiceMetrics, 2018). To avoid any ordering effect, these scenarios were presented in random order to each respondent, who is then asked to choose his or her preferred scenario. To facilitate understanding of the monetary attribute, the price increase per kWh is also expressed as a change in the electricity bill. A total of 393 valid questionnaires were collected, resulting in 4716 (12x393) observations.

#### *Descriptive statistics*

The survey took place in the Upper Normandy region (France), which is composed of two counties (“*départements*”): Seine Maritime and Eure. Women represent 51.5% of the 393 responses in our sample which is representative of the French population, at a county level and a national level. The average age of the respondents is 44 years. Nearly 38% have a level of education higher than two years after high school. The average individual income is €2,210. 59% of the respondents live in an apartment and 41% in a house. 40% of the respondents own their home.

Two-thirds of the respondents said they had already heard about the energy transition and were able to briefly define it.

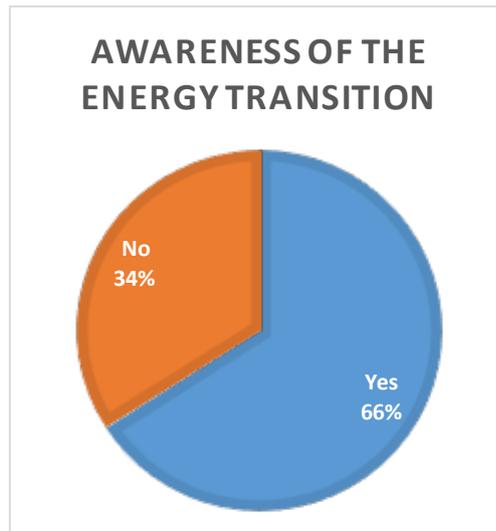


Figure 1: Awareness of energy transition

Respondents' awareness of photovoltaic and wind power is high, regardless of whether or not they know about energy transition. Methanization appears to be much less known by the population. Only a quarter of the people surveyed were aware of this renewable source of energy.

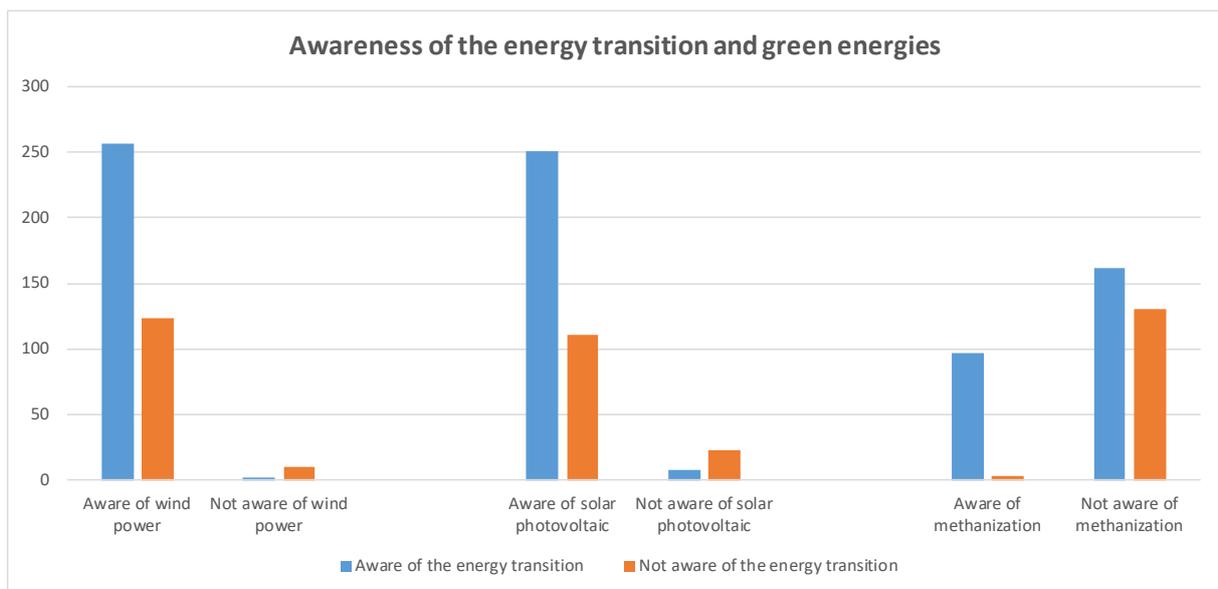


Figure 2: Awareness of the energy transition and green energies

As mentioned earlier, the survey included a detailed (one-page flyer) presentation of each of the three renewable energies. One question was then asked to check whether the respondents had clearly understood each presentation, which was the case for about 90% of them.

The average electricity bill per household per month is €75 with a standard deviation of €46, which is in line with the national figures.

Finally, as can be seen from the following Figure, most of the respondents agree or strongly agree with the idea that the energy transition is crucial. Likewise, a vast majority considers that the additional cost of green electricity should be paid by green electricity consumers.

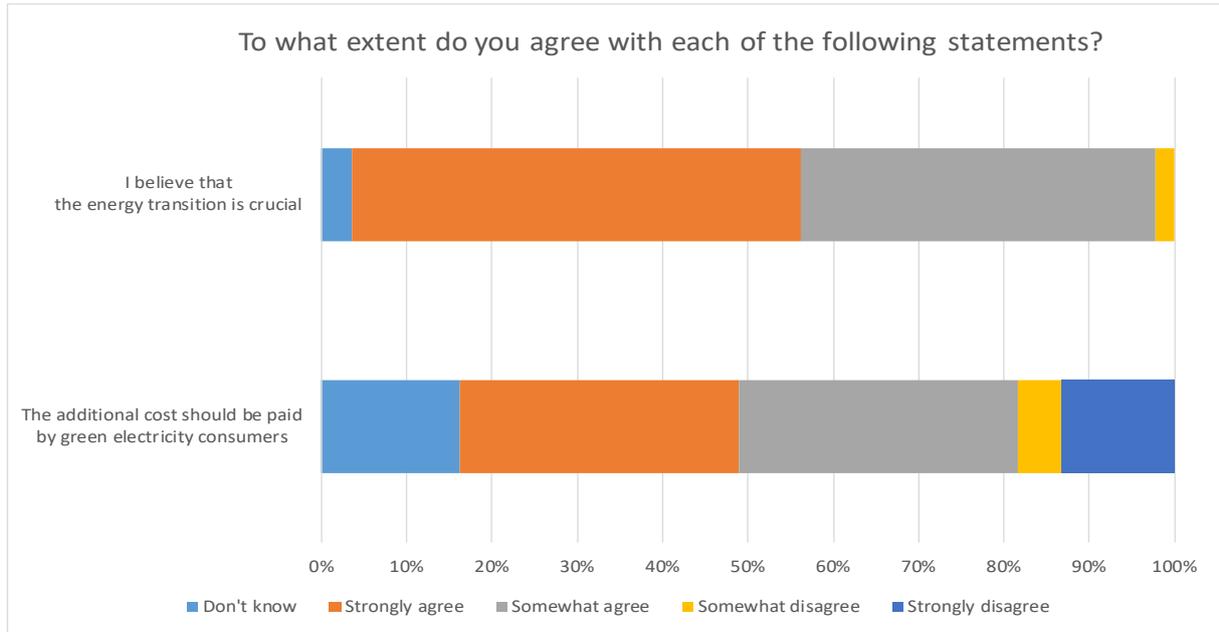


Figure 3: Attitudes towards the energy transition

We now turn to the description of the modelling work, *i.e.*, the description of the hybrid choice model.

#### 4. Modelling work

Typical hybrid choice models have three components: a discrete choice model, a structural component and a measurement component (Budziński and Czajkowski, 2022).

We start with *the choice model part*. Each respondent  $n$  successively faces  $T$  choice tasks made up of  $i$  alternatives, where  $T=12$  and  $i=4$  in the context of this paper. Each alternative is composed of a modelled component  $V_{int}$  and an error term  $\epsilon_{int}$  which is assumed to follow a type 1 extreme value distribution. We have:

$$U_{int} = V_{int} + \epsilon_{int}$$

For each alternative, it comes that (omitting non-essential subscripts  $n$  and  $t$ ):

$$U_1 = (\beta_{wind}x_{wind1} + \beta_{photo}x_{photo1} + \beta_{metha}x_{metha1} - x_{cost1}) \cdot \beta_{cost} + \epsilon_1$$

$$U_2 = (\beta_{wind}x_{wind2} + \beta_{photo}x_{photo2} + \beta_{metha}x_{metha2} - x_{cost2}) \cdot \beta_{cost} + \epsilon_2$$

$$U_3 = (\beta_{wind}x_{wind3} + \beta_{photo}x_{photo3} + \beta_{metha}x_{metha3} - x_{cost3}) \cdot \beta_{cost} + \epsilon_3$$

$$U_4 = \beta_{status\ quo} + (\beta_{wind}x_{wind4} + \beta_{photo}x_{photo4} + \beta_{metha}x_{metha4} - x_{cost4}) \cdot \beta_{cost} + \epsilon_4$$

Where the  $\beta$  parameters correspond to preferences for each of the attributes to be estimated (and where  $\beta_{status\ quo}$  captures the preference for not moving towards an energy transition program. The variables labelled  $x$  correspond to the attribute levels faced by respondents. The model is estimated in *Willingness-To-Pay space* since  $\beta_{cost}$  is used as a scaling factor for  $\beta_{wind}$ ,  $\beta_{photo}$  and  $\beta_{metha}$ , meaning that these parameters can be directly interpreted as Willingness-To-Pay (WTP) measures. Note that given the questionnaire design, WTP are expressed in euro cents for an additional percentage point of the renewable energy considered in the energy mix.

Preferences are allowed to vary randomly across respondents. More precisely:

$$\beta_{wind} = \mu_{wind} + \sigma_{wind1} \cdot \zeta_{wind} + \kappa_{wind} \cdot \alpha$$

$$\beta_{photo} = \mu_{photo} + \sigma_{photo1} \cdot \zeta_{wind} + \sigma_{photo2} \cdot \zeta_{photo} + \kappa_{photo} \cdot \alpha$$

$$\beta_{metha} = \mu_{metha} + \sigma_{metha1} \cdot \zeta_{wind} + \sigma_{metha2} \cdot \zeta_{photo} + \sigma_{metha3} \cdot \zeta_{metha} + \kappa_{metha} \cdot \alpha$$

$$\beta_{status\ quo} = \mu_{status\ quo} + \sigma_{status\ quo1} \cdot \zeta_{wind} + \sigma_{status\ quo2} \cdot \zeta_{photo} + \sigma_{status\ quo3} \cdot \zeta_{metha} + \sigma_{status\ quo4} \cdot \zeta_{status\ quo} + \kappa_{status\ quo} \cdot \alpha$$

$$\beta_{cost} = e^{(\mu_{cost} + \sigma_{cost} \cdot \zeta_{cost})}$$

Where the  $\mu$  parameters correspond to the mean of the distribution of preferences for each energy source (expressed in monetary units).  $\zeta_{wind}$ ,  $\zeta_{photo}$  and  $\zeta_{metha}$  are sets of draws. Their distribution is  $N \sim (0,1)$ . Hence, it is implied that the preferences for each energy source are normally distributed. More precisely, the distributions are assumed to be multivariate normal, that is the distributions for each energy sources are assumed to be correlated with one another. This is performed by the means of a Cholesky decomposition, where  $\sigma_{wind1}$ ,  $\sigma_{photo2}$  and  $\sigma_{metha3}$  are the diagonal elements and  $\sigma_{photo1}$  and  $\sigma_{metha2}$  the off-diagonal elements of the Cholesky matrix.

The parameter  $\beta_{status\ quo}$  is specified in a similar fashion and is correlated with the other non-monetary attributes *via*  $\sigma_{status\ quo1}$ ,  $\sigma_{status\ quo2}$ ,  $\sigma_{status\ quo3}$  and  $\sigma_{status\ quo4}$ . Finally,  $\beta_{cost}$  is assumed to be log-normally distributed, which is a very standard assumption in the literature and is important to guarantee that the WTP estimates have finite moments.

The variable  $\alpha$  is a latent variable which seeks to capture the effect of awareness of *energy transition* on preferences. Its meaning is derived from the *structural component* of the model that, in HCMs, links the latent variables to exogenous factors. It is specified as follows:

$$\alpha_n = \alpha_{female} S_{female} + \alpha_{income} S_{income} + \eta_\alpha$$

Where  $\alpha_{female}$  and  $\alpha_{income}$  capture the effect of *gender* and *income* on the value of the latent variable and  $\eta_\alpha$  is a disturbance term which is distributed  $N \sim (0,1)$ .

In turn,  $\kappa_{wind}$ ,  $\kappa_{photo}$ ,  $\kappa_{metha}$  and  $\kappa_{status\ quo}$  captures the influence of the latent variable on the  $\beta$ 's *i.e.* on the preferences for each of the attributes within what is usually referred to as the *measurement component* of HCMs.

More precisely, the latent variable  $\alpha$  enters the likelihood function of two indicators related to the stated awareness of respondents regarding what the energy transition is and what methanization is which correspond to:

$$I_{transition} = \frac{e^{(\tau_{transition} + \kappa_{transition} \cdot \alpha_n)}}{1 + e^{(\tau_{transition} + \kappa_{transition} \cdot \alpha_n)}} \cdot (Y_{transition} = 1) + \frac{1}{1 + e^{(\tau_{transition} + \kappa_{transition} \cdot \alpha_n)}} \cdot (Y_{transition} = 0)$$

$$I_{methanization} = \frac{e^{(\tau_{methanization} + \kappa_{methanization} \cdot \alpha_n)}}{1 + e^{(\tau_{methanization} + \kappa_{methanization} \cdot \alpha_n)}} \cdot (Y_{methanization} = 1) + \frac{1}{1 + e^{(\tau_{methanization} + \kappa_{methanization} \cdot \alpha_n)}} \cdot (Y_{methanization} = 0)$$

Indicators related to the self-reported awareness of the other renewable energy sources considered in this survey have not been included in the model because of a lack of variability in the data: as Figure 2 shows, most respondents stated that they are aware of these energy sources (wind power and solar photovoltaic). Including these indicators in the model hence led to convergence issues as well as multicollinearity issues.

Where  $\tau_{transition}$  and  $\tau_{methanization}$  are constants and where  $\kappa_{transition}$  and  $\kappa_{methanization}$  capture the effect of variations of the latent variable  $\alpha$  on the likelihood of a given respondent to state that they are aware (or not aware) of methanization and the energy transition.

Regarding identification of the model, we follow recent recommendations from Budziński and Czajkowski (2022) by checking that the necessary condition derived by Bollen and Davis (2009) as the “2+ emitted path rule” for structural equation models is met. To quote Bollen and Davis (2009), “the 2+ emitted paths rule states that each latent variable must emit at least two paths to latent or observed variables and is applied latent variable by latent variable.” In our specifications, this necessary condition is met, as the latent variable has two unique indicators in the measurement component of the HCM.

The overall likelihood of the model corresponds to the joint probability of observing the sequence of  $T$  choices for respondent  $n$  conditional on the vector of taste coefficients  $\beta_n$ , the parameters  $\zeta$  and the latent variable  $\alpha_n$ . In the context of this paper, the likelihood is a product of 12 multinomial logit choice probabilities labelled as  $L(C_n | \beta_n, \kappa, \alpha_n)$  where  $C_n$  is a choice indicator. Moreover, let  $L(I_n | \tau, \kappa, \alpha_n)$

give the probability of observing the actual values for the two indicator variables introduced above. The overall likelihood over the  $N$  respondents corresponds to the product of the various model components and is given by:

$$L(\beta, \kappa, \tau, \alpha) = \sum_{n=1}^N \int_{\beta} \int_{\eta} L(C_n | \cdot) L(I_n | \cdot) g(\eta) m(\beta) d\eta d\beta$$

Where this is integrated over the distribution of  $\eta$  which is the random component in  $\alpha$  as well as the randomly distributed vector of preferences and WTP coefficients  $\beta$ . It is clear from the equations above that both the choices made during the *Stated Preferences* exercise and the responses to the indicators are a function of the latent variable  $\alpha$ . Variations in  $\alpha$  jointly affect preferences as well as the likelihood of being aware or not of methanization and the *energy transition*, thus giving rise to the opportunity of controlling for the effect of awareness on preferences while at the same time accounting for well-known issues related to measurement error for the indicator variables. Different respondents have different perceptions of what *being aware* truly involves, and allowing these variables to enter the model as indicators rather than interaction variables ensures that *measurement error* is controlled for (given that each indicator is introduced as a stochastic process rather than an absolute measure of awareness).

## 5. Results

Model results are reported in Table 4 below. The model has been estimated using 10,000 Halton draws and analytical derivatives have been used for both the estimation of the parameters and the computation of the hessian from which the robust standard errors of the parameters are derived<sup>1</sup>.

<b>Log-Likelihood</b>		-4089.61		
<b>R2</b>		0.4226		
<b>AIC</b>		8231.22		
<b>BIC</b>		8399.15		
<b>Parameter</b>		<b>Value</b>	<b>Rob. Std. err.</b>	<b>Rob. T-ratio</b>
$\mu$	<i>status quo</i>	-7.1458	3.5359	-2.02
	<i>wind</i>	0.7088	0.1422	4.95
	<i>photo</i>	1.1023	0.3619	3.04
	<i>metha</i>	0.4407	0.1296	3.39
	<i>cost</i>	-1.1027	0.1833	-6.01
$\sigma$	<i>cost</i>	0.9273	0.1591	5.82
	<i>wind1</i>	-1.1665	0.2357	-4.94
	<i>photo1</i>	0.1318	0.1405	0.93
	<i>photo2</i>	-1.5313	0.2157	-7.37
	<i>metha1</i>	0.3463	0.0986	3.51
	<i>metha2</i>	0.1472	0.0640	2.29
	<i>metha3</i>	1.2846	0.1737	7.39

<sup>1</sup> Estimations were done using the Apollo package (Hess and Palma, 2019) and performed on computing resources (Myria supercomputer) provided by CRIANN (Normandy, France).

	<i>status quo1</i>	17.7349	3.0863	5.74
	<i>status quo2</i>	3.6872	2.1802	1.69
	<i>status quo3</i>	-5.9823	2.0686	-2.89
	<i>status quo4</i>	-1.9495	0.4388	-4.44
$\kappa$	<i>wind</i>	-0.1666	0.1013	-1.64
	<i>photo</i>	0.0117	0.0833	0.14
	<i>metha</i>	-0.2439	0.0901	-2.70
	<i>status quo</i>	0.0281	1.6782	0.01
	<i>transition</i>	-3.0916	0.9978	-3.09
	<i>methanization</i>	-2.7125	0.6441	-3.90
$\tau$	<i>transition</i>	1.1478	0.4989	2.30
	<i>methanization</i>	-2.6801	0.6493	-4.12
$\alpha$	<i>female</i>	0.6300	0.1431	4.40
	<i>income</i>	-0.8111	0.1226	-6.61

Table 4: Results

#### *Choice model component*

We start by describing the results of the choice model component and first focus on the means of the distribution of preferences for the different non-monetary attributes, which are labelled as the  $\mu$  parameters in Table 1 above. We first observe that respondents are strongly in favour of moving away from the *status quo* and increase the share of renewable energies in the French energy mix *all else being equal* because the value of  $\mu_{status\ quo}$  is found to be negative (-7.1458) and significant at the 5% level (Rob. T. = -2.02). This can be explained by the fact that the *status quo* alternative (labelled as  $U_4$  above) has only been selected 15.5% of the time by respondents, which makes it the least preferred alternative (the rest of the alternatives are not labelled, meaning that whether alternative 1, 2 or 3 has been chosen instead is irrelevant<sup>2</sup> for policy making).

Respondents are found to be willing-to-pay for increasing the share of each one of the three renewable energy sources considered in the French energy mix. More precisely, the most preferred attribute is found to be solar photovoltaic for which the mean marginal WTP (mWTP) is found to be €c1.10 (for an additional percentage point of solar photovoltaic in the energy mix), followed by wind power (€c0.70) and finally methanization (€c0.44). Looking at Figure X below as well as the elements of the Cholesky decomposition reported in Table 1, we find significant heterogeneity in preferences across the population for the different attributes. It is of particular interest to investigate the share of respondents who derive a negative mWTP from each one of the renewable energy sources considered in this survey as this gives an indication of the proportion of individuals in the general population who are likely to reject the energy policies discussed in this paper. The share of respondents who derive a negative utility from the *status quo* is 64.52%, which is in line with the parameter value for  $\mu_{status\ quo}$

<sup>2</sup> This would not be true if ordering effects and lexicographic preferences would have been found to be a concern (for example, respondents constantly choosing the first alternative). However, this has not been the case here and therefore the model only features one Alternative Specific Constant related to the *status quo* alternative, which also allows to make the model more parsimonious in parameters given that a full-Cholesky decomposition is introduced.

as previously discussed. The share of respondents for whom the mWTP is negative is 23.63% for solar photovoltaic, 27.32% for wind power and 37.25% for methanization.

The parameters related to heterogeneity in preferences and involved in the Cholesky decomposition as well as the parameter used in the hybrid model structure and labelled as  $\kappa$  also allow to measure the correlation between the distributions of taste heterogeneity for the different attributes as well as the status quo. The results, which are obtained by the means of simulation methods (using 10,000,000 draws) are reported in Table 5 below.

	<i>Status quo</i>	<i>Wind</i>	<i>Photo</i>	<i>Metha</i>
<i>Status quo</i>				
<i>Wind</i>	-0.9156			
<i>Photo</i>	-0.1124	-0.0861		
<i>Metha</i>	-0.0393	-0.2264	-0.0869	

Table 5: Correlations between the distributions of taste heterogeneity for the different attributes including the status quo.

We note that *status quo* is extremely negatively correlated with *Wind*, meaning that moving away from the *status quo* is associated with a strong support for wind power. At the same time, the other energy sources are only weakly correlated with *status quo*, meaning that the mWTP for these renewable energy sources is negatively associated with supporting the *status quo*, but to a much lesser extent than it is for wind power. The distribution of mWTP for increasing wind power is negatively correlated with increasing solar photovoltaic and methanization. In turn, the mWTP distributions for methanization and solar photovoltaic are negatively correlated with one another. While these effects are not very strong, they indicate that respondents have a tendency to support one particular type of renewable energy over others, with an overall preference for wind power.

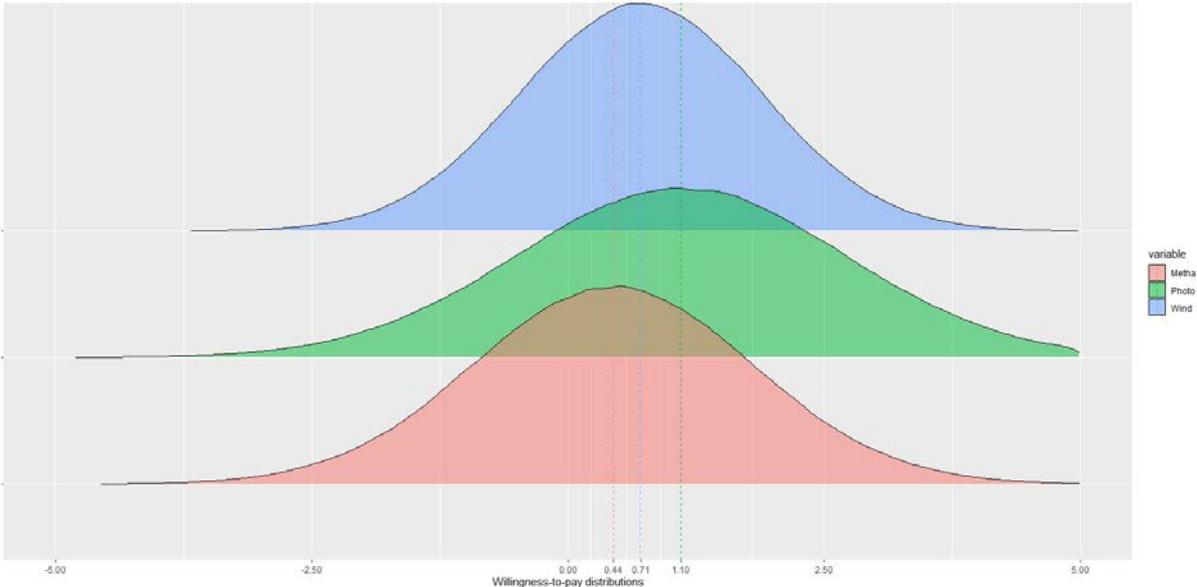


Figure 4: Willingness-to-pay for the three green electricity sources

Hybrid component

We now focus on the hybrid features of the choice model and how they interact with preferences and, ultimately, mWTP. As previously stated, the latent variable  $\alpha$  is assumed to influence the mWTP for each of the three sources of renewable energy considered as well as the likelihood of observing whether respondents declare to be aware of what the energy transition is and what methanization is. It is hence assumed that the latent variable is broadly related to respondents' awareness of renewable sources of energy. In the remainder of the paper, we simply refer to it as  $\alpha$ . Interpreting the effects of the latent variable requires to jointly look at its effects on the mWTP and the indicators. We illustrate this by looking at how the variations of  $\alpha$  jointly affect the mWTP for methanization and the likelihood that a respondent reports that she is aware of what methanization and the energy transition are. This is performed by looking at the parameters labelled as  $\kappa$  in Table X. We observe that  $\kappa_{metha}$  is negative (-2.7125) and significant at the 1% level (T = -3.90). This means that when the latent variable  $\alpha$  increases, the mWTP for methanization decreases, as illustrated by Figure 4 below. This in itself does not indicate whether respondents who declare to be aware of methanization are willing to pay less for it. It is necessary to also look at the sign of  $\kappa_{methanization}$  which is negative (-0.2439) and significant at the 1% level (T = -2.70). Thus, when  $\alpha$  increases, the probability of the respondent stating that she is aware of what methanization is, decreases. Altogether, this means, given how the likelihood of  $I_{methanization}$  and the choice model have been specified, that a decrease of  $\alpha$  actually leads to an increase of the mWTP for methanization, as well as an increase of the probability that a given respondents has stated that she is aware of what methanization is. In other words, respondents who are willing-to-pay more for methanization are also more likely to claim that they are aware of what it is. Likewise, respondents who are willing to pay more for methanization are also more likely to claim that they are aware of what energy transition is.

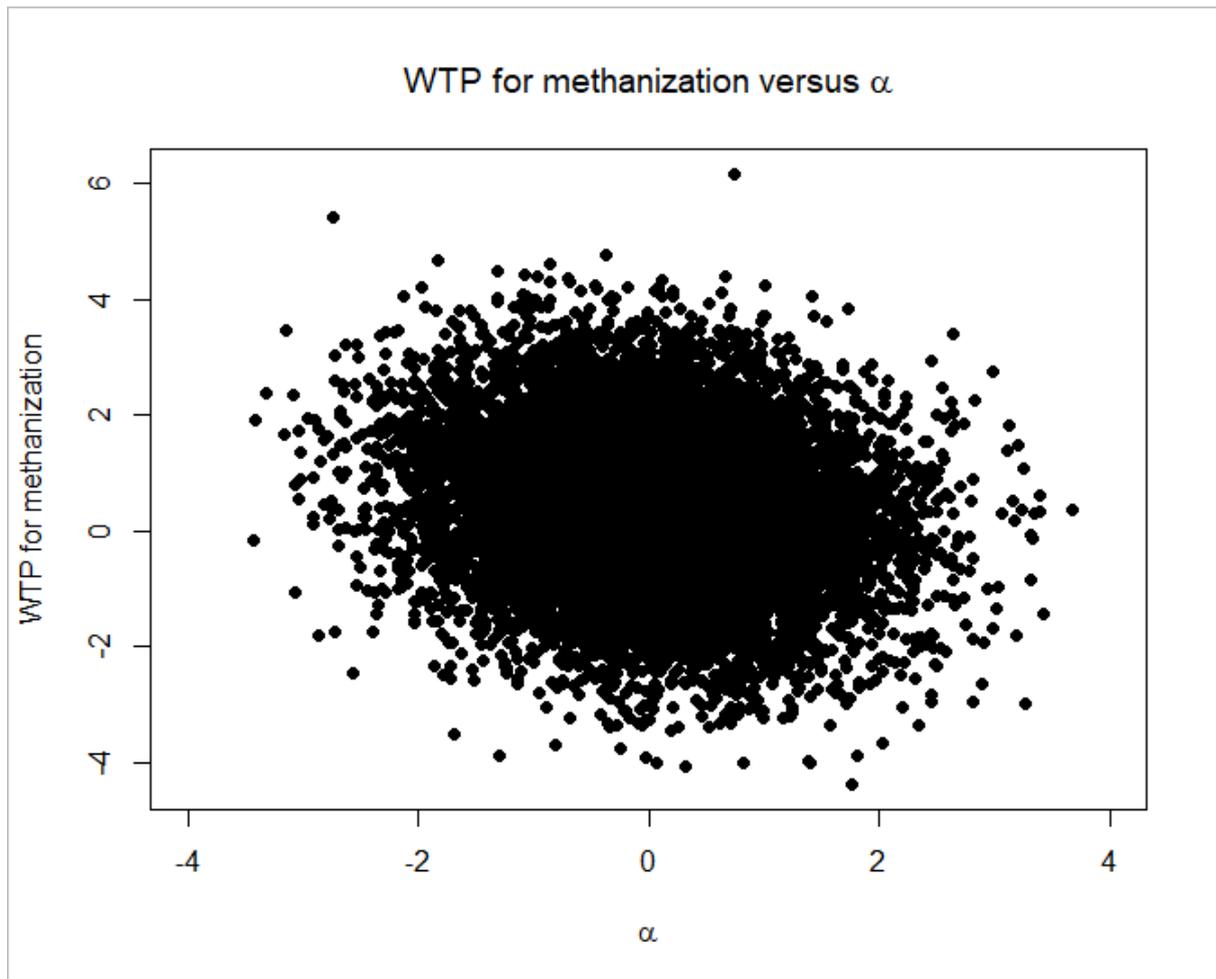


Figure 5: Willingness-to-pay versus  $\alpha$

A similar effect is found for wind power while the opposite effect is found for solar photovoltaic.

These effects are reported in Table 6 below and further discussed in the remainder of this section.

	$\alpha$								
	-2	-1.5	-1	-0.5	0	0.5	1	1.5	2
<i>WTP_WIND</i>	1.04	0.96	0.88	0.79	<b>0.71</b>	0.63	0.54	0.46	0.38
<i>WTP_PHOTO</i>	1.08	1.08	1.09	1.10	<b>1.10</b>	1.11	1.11	1.12	1.13
<i>WTP_METHA</i>	0.93	0.81	0.68	0.56	<b>0.44</b>	0.32	0.20	0.07	-0.05
<i>PROB_KNOW_TRANS</i>	0.999	0.997	0.986	0.937	<b>0.759</b>	0.402	0.125	0.030	0.006
<i>PROB_KNOW_METHA</i>	0.940	0.800	0.508	0.210	<b>0.064</b>	0.017	0.005	0.001	0.000

Table 6: Effects of  $\alpha$  on indicators and mWTP estimates

When the value of  $\alpha$  is 0, the mWTP values for each one of the three energy sources correspond to the average WTP values discussed above<sup>3</sup> and the order of preferences is *solar photovoltaic* > *wind power* > *methanization*. When  $\alpha$  is 0, the probability of a respondent reporting that she is aware of the energy transition corresponds to 0.759 while the probability that she reports to be aware of methanization has a lower value (0.064).

When  $\alpha$  is equal to -2, the mWTP for *Wind* is equal to 1.04 while it is 1.08 for *solar photovoltaic* and 0.93 for *methanization*. While the order of preferences has not changed, the mWTP for methanization is now much closer to the mWTP for solar and wind power. On the other hand, when  $\alpha$  is equal to 2,  $I_{transition}$  and  $I_{methanization}$  are both almost equal to zero while the mWTP for methanization becomes negative (-0.05). The mWTP for wind power decreases to 0.38 while the mWTP for solar power increases to 1.13. It is worth noting looking at Table X that the mWTP for solar power remains almost unaffected by  $\alpha$ . This result was expected given that  $\kappa_{solar}$  is not significant and only equal to 0.0117. Finally, we find that a higher income decreases the value of the latent variable (leading to higher mWTP and likelihood of reporting to be aware of methanization and the energy transition) while being female has the opposite effect. Altogether, these results add a layer of behavioural insights and show how the preferences for renewable energy and the knowledge about them are interrelated. The relevance of these results for policy making is discussed in the next section.

## 6. Summary and conclusion

Identifying the enabling conditions of the fight against global warming requires a deeper understanding of individual preferences for green energy, especially for green electricity. To this end, we conducted a discrete choice experiment designed to assess how respondents' awareness of three RE sources, photovoltaic solar, wind power and methanization actually shapes WTP for these three RE sources. The data collected are analysed by estimating a hybrid choice model which allows us both to address the issue of measurement error posed by the variables that capture the stated respondents' awareness and to better model preference heterogeneity.

We find clear support for green electricity. About two third of the respondents reject the status quo option, in favour to a move towards larger shares of photovoltaic, wind power and methanization in the French electricity mix. We also find a clear ranking of the three RE sources: respondents are willing

<sup>3</sup> This is perfectly in line with expectations given that the latent variable is centred around zero. The likelihood values for each of the two indicators also correspond to the percentage of respondents who have reported that they were aware of the energy transition or of methanization.

to pay more for photovoltaic power, then for wind power and to a lesser extent for methanization. Awareness of the energy transition and of methanization is positively associated with mWTP. Income is found to be positively associated with awareness while being female is negatively associated with awareness. Also, our modelling framework allows us to compute correlation between the DCE attributes, showing that the status quo option is strongly and negatively correlated with wind power. The latter result suggests that wind power is perceived as a clear solution towards energy transition.

However, modelling preference heterogeneity also allows us to show that between one quarter (photovoltaic solar) and one third (methanization) is not willing to pay at all for green electricity. Likewise, respondents seem to exhibit strong preference for one or another green energy source rather than for all the green energy sources.

In terms of guidance for policy-makers our results suggest that awareness of green energy sources could play an important role in the adoption of green electricity plan by consumers. In our survey, respondents are well aware of photovoltaic and wind power which has a positive impact on their willingness-to-pay for these RE. As awareness of methanization is low, so is the willingness-to-pay for methanization, leaving space for better information targeted on this specific RE. Finally, as public spending in renewable infrastructure is expected to grow fast, our results suggest that regulators and electricity marketers should pay particular attention to the matching of green electricity products with consumers' preferences.

## References

- Akcura E. (2015). "Mandatory versus voluntary payment for green electricity", *Ecological Economics* 116, pp. 84-94.
- Akinwehinmi O., Ogundari K., Amos, T. (2021). "Consumers' food control risk perception and preference for food safety certification in emerging food markets", *Journal of Agricultural Economics*.
- Andor M.A., Frondel M., Vance C. (2017). "Germany's Energiewende: A Tale of Increasing Costs and Decreasing Willingness-To-Pay", *The Energy Journal*, 38, pp. 211-228.
- Andor M., Frondel M., Sommer S. (2018). "Equity and the Willingness to Pay for Green Electricity: Evidence from Germany", *Nature Energy*, vol. 3, pp. 876-881.
- Bae J.H., Rishi M. (2018). "Increasing Consumer Participation Rates for Green Pricing Programs: A Choice Experiment for South Korea", *Energy Economics* 74, pp.490-502.
- Bakkensen P., Schuler P. (2020). "A preference for power: Willingness to pay for energy reliability versus fuel type in Vietnam", *Energy Policy* 144, pp.1-9.
- Bollen, K. A. and Davis, W. R. (2009). Two Rules of Identification for Structural Equation Models. *Structural Equation Modeling: A Multidisciplinary Journal* 16: pp. 523-536.
- Bollino, C.A., 2009. "The willingness to pay for renewable energy sources: the case of Italy with socio-demographic determinants", *The Energy Journal*, 30 (2), pp. 81–96.
- Bourcet C. (2020). "Empirical determinants of renewable energy deployment: A systematic literature review", *Energy Economics*, 85, pp.1-19.
- Budziński, W., Czajkowski, M. (2022). Endogeneity and measurement bias of the indicator variables in hybrid choice models: A Monte Carlo investigation, *Environmental and Resource Economics* forthcoming.
- Cardella E., Ewing B. T., Williams R. B. (2022). "Green is Good—The Impact of Information Nudges on the Selection of Voluntary Green-Power Plans", *The Energy Journal*, vol. 43(1).
- Cheng Y.S., Cao K.H., Woo C.K., Yatchem A. (2017). "Residential willingness to pay for deep decarbonization of electricity supply: Contingent valuation evidence from Hong Kong", *Energy Policy* 109, pp. 218-227.
- ChoiceMetrics. (2018). Ngen 1.2 User Manual and Reference Guide. ChoiceMetrics.
- Conte M.N., Jacobsen, G.D. (2016). "Explaining Demand for Green Electricity Using Data from All U.S. Utilities", *Energy Economics* 60, pp. 122–130.
- Gracia A., Barreiro-Hurlé J., Pérez y Pérez L. (2012). "Can renewable energy be financed with higher electricity prices? Evidence from Spanish region", *Energy Policy* 50, 784-794.
- Herbes C., Rilling B., MacDonald S., Boutin N., Bigerna S. (2020). "Are voluntary markets effective in replacing state-led support for the expansion of renewables? – A comparative analysis of voluntary green electricity markets in the UK, Germany, France and Italy", *Energy Policy*, 141.

Hess, S. and Palma, D. (2019), "Apollo: a flexible, powerful and customisable freeware package for choice model estimation and application", *Journal of Choice Modelling*, 32.

Hess S., Stathopoulos, A. (2013). "Linking response quality to survey engagement: a combined random scale and latent variable approach.", *Journal of Choice Modelling*, 7, 1-12.

I4CE (2020). "Investing in climate can help France drive its economic recovery", Institute for Climate Economics, Paris, April 2020.

IPCC (2022). Working group III contribution to the IPCC sixth assessment report (AR6). Summary for Policymakers, April 2022.

Johnston, R.J., Boyle, K.J., Adamowicz, W., Bennett, J., Brouwer, R., Cameron, T.A., Hanemann, W.M., Hanley, N., Scarpa, R., Tourangeau, R., Vossler, C.A. (2017). "Contemporary guidance for stated preference studies.", *Journal of the Association of Environmental and Resource Economists.*, 4(2), pp. 319-405.

Kim J., Park J., Kim J., Heo E. (2013). "Renewable electricity as a differentiated good? The case of the Republic of Korea", *Energy Policy* 54, pp. 327–334.

Kim J.-K., Lee H-J, Yoo S.-H. (2018). "Are South Korean people willing to pay for official development assistance for building renewable power plants in developing countries?", *Energy Policy* 118, pp. 626-632.

Knapp L., O'Shaughnessy E., Heeter J., DeCicco J.M., Mills S. (2020). "Will consumers really pay for green electricity? Comparing stated and revealed preferences for residential programs in the United States", *Energy Research & Social Science* 65, 101457.

Mamkhezri, J., Thacher, J. A., Chermak, J. M. (2020). "Consumer Preferences for Solar Energy: A Choice Experiment Study", *The Energy Journal*, 41(5), pp. 157-183.

Motz A. (2021). "Consumer acceptance of the energy transition in Switzerland: The role of attitudes explained through a hybrid discrete choice model", *Energy Policy* 151, pp. 112-152

Paravantis J.A., Stigka E., Mihalakakou G., Michalena E., Hills J.M., Dourmas V. (2018). "Social acceptance of renewable energy projects: A contingent valuation investigation in Western Greece", *Renewable Energy* 123, pp. 639-651.

Soland M., Steimer N, Walter G. (2013). "Local acceptance of existing biogas plants in Switzerland", *Energy Policy* 61, pp. 802-810.

Solino M., Farizo B.A., Vazquez M.X., Prada A. (2012). "Generating electricity with forest biomass: Consistency and payment timeframe effects in choice experiments", *Energy Policy* 41, pp. 798-806

Soon J.J., Ahmad S.A. (2015). "Willingly or grudgingly? A meta-analysis on the willingness-to-pay for renewable energy use". *Renewable Sustainable Energy Review* 44, pp. 877-887

Stigka, E.K., Paravantis, J.A., Mihalakakou, G.K (2014). "Social acceptance of renewable energy sources: a review of contingent valuation applications", *Renewable Sustainable Energy Review* 32, pp. 100–106.

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

Upreti B.R., Van de Horst D. (2004). "National renewable energy policy and local opposition in the UK: the failed development of a biomass electricity plant", *Biomass and Bioenergy* 26(1), pp.61-69.

Wall W. P., Khalid B., Urbański M., Kot M. (2021). "Factors Influencing Consumer's Adoption of Renewable Energy", *Energies*, 14, 5420.

Xie B.-C., Zhao W. (2018). "Willingness to pay for green electricity in Tianjin, China: Based on the contingent valuation method", *Energy Policy* 114, pp. 98-117.

Zoellner J., Schweizer-Ries P., Wemheuer (2008). "Public Acceptance of renewable energies: Results from case studies in Germany", *Energy Policy*, pp. 4136-4141.

Zografakis, N., Sifaki, E., Pagalou, M., Nikitaki, G., Psarkis, V., Tsagarakis, K.P. (2010). "Assessment of public acceptance and willingness to pay for renewable energy sources in Crete". *Renewable and Sustainable Energy Reviews*, 14 (3), pp. 1088–1095.

Zoric J., Hrovatin N (2012). "Household willingness to pay for green electricity in Slovenia", *Energy Policy* 47, pp. 180-187.