Consumer preferences and the energy transition[1]

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1. Introduction

In the aftermath of the Fukushima nuclear accident in 2011, the Swiss Federal Council and Parliament discussed and approved an update of the national energy strategy, providing for the gradual decommissioning of the existing nuclear plants in the country. The new "Swiss Energy Strategy 2050" resulting from this initiative encompasses a wide set of actions: among these, the provisions concerning the electricity sector focus on ensuring the security and sustainability of electricity supply by upgrading the country's generation fleet and transmission and distribution grids.

A first bundle of practical measures, whose implementation is scheduled starting from 2018, fosters therefore the expansion of renewable-based, low carbon generation facilities to make up for the decreasing contributions from nuclear plants. Within this scenario net productions from hydroelectric plants, already contributing to almost 60% of national productions, are held roughly constant, whereas productions from non-hydro, renewable-based plants should see a fourfold increase by 2035 with respect to 2015 levels. Solar and wind are expected to play the main role, with smaller contributions from biogas, wood, waste, and geothermal energy.

Practical measures concerning the upgrading of electricity grids are moreover under discussion in the Swiss Parliament. The need of enabling increasing intakes from distributed, intermittent renewables, and setting clear framework conditions for the roll-out of smart meters has already been recognized and partially included in the draft "Electricity grid strategy".

The technological, economic and regulatory challenges posed by the energy transition are constantly studied from a supply-side perspective. In recent times increasing attention has been paid to demand-side aspects as well, in order to assess the potential contributions from demand response and evaluate the acceptance of new technologies from both local communities, and individual consumers. This approach is particularly relevant to the Swiss case, as energy policies and infrastructural projects can be hindered by means of national and cantonal referenda[4]. Accurate information concerning citizens'

[1] We gratefully acknowledge support from the Swiss National Science Foundation, Grant CR12I1_140740.

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[4] Since the approval of the Swiss Energy Strategy 2050 three referenda on energy-related topics have been called on a national level: the popular initiative "For a sustainable and resource-efficient economy (Green Economy)" in September 2016, the popular initiative "For an orderly withdrawal from the nuclear energy programme (Nuclear Withdrawal Initiative)" in November 2016, and finally the referendum on the "Energy Strategy 2050, first implementation package – Federal Law on Energy 30th September 2016" in May 2017.

preferences and their drivers is thus crucial in order to design successful policies, and facilitate the achievement of the desired energy policies and infrastructural goals.

The goal of this study is contributing to the shaping and management of the energy transition in Switzerland by assessing the preferences of Swiss residential consumers with respect to the primary energy sources used for generating electricity, while accounting for their preferences with respect to variations in the risk of experiencing short and long blackouts. By means of a discrete choice (DC) experiment on stated preferences, we model the respondents' preferences toward the above-mentioned features of electricity supply, and account for the influence of socio-economic, behavioural and attitudinal variables thereon. The information we gather on consumers' preferences toward greener supply options and their willingness-to-pay (WTP) for a safer supply can inform decision-making as regards the kind of investments and the amount of resources that could be available for specific objectives. Our analysis of consumers' tastes and on the drivers of their heterogeneity, on the other hand, may support the definition of policies and strategies that minimize local opposition and facilitate the achievement of the desired goals.

2. Literature review

In the last two decades several analyses have investigated consumers' preferences with respect to specific features of energy-related goods and services, among which electricity supply. Indeed, this topic has become increasingly popular in parallel with:

- the need of tackling environmental problems connected to energy production and use on the one hand, the stronger environmental awareness of consumers on the other hand,
- the need of addressing security of supply issues, and hence quantifying the cost of supply interruptions for different consumer classes, including households,
- the liberalization wave that has been spreading in the energy sector since the late 1980s, leading to an increased diversification of energy supply contracts.

Existing analyses on consumers' preferences with respect to "green" energy options generally use contingent valuation techniques, DC experiments, or multiple regressions on stated preferences data. Most studies concerning electricity supplies to households, although not fully comparable due to differences in both the elicitation techniques, and the geographical and institutional settings, suggest a positive and significant WTP for an increase in the contribution of renewable sources, as shown in the reviews of Bollino C. A. 2009, and Zoric J. & Hrovatin N. 2012. A positive WTP for green options is also often found in similar studies concerning adoption of renewable-based or energy-efficient home appliances, engagement in community renewable energy projects, and individual carbon off-set behaviours.

Looking at the individual drivers of these preferences, the surveyed literature suggests that the typical socio-economic variables such as age, gender, income, and unit or monthly cost of electricity generally show limited or conflicting impacts, whereas behavioural and attitudinal variables play a stronger role. Behavioural drivers that are often associated to a higher probability of choosing a green option are the regular adoption of energy saving behaviours, and the familiarity with the own energy supplier [Blasch J. et al. 2017, Yang Y. et al. 2016]; the contrary holds for the tendency to stay with the default option provided by the own energy supplier [Kaenzig J. et al 2013]. Individual knowledge and interests in energy-related topics can also push towards the adoption of green options: this is indeed the case for a higher energy and investment literacy, a good understanding of the actual meaning of green labels, and a realistic idea of the price premium for green electricity [Blasch J. et al 2017, Tabi A. et al 2014]. Among attitudinal drivers a strong environmental awareness, a pro-environmental attitude, and the perception of a higher effectiveness of individual behaviours or societal actions in coping with climate change, are usually associated to a higher WTP or probability of choosing the green options [Ward D.O. et al. 2011, Zoric J. & Hrovatin N. 2012, Bauwens T. 2016, Tabi A. et al 2014]. More general attitudinal motives for engaging in green choices or participating in community renewable generation projects are often found in feelings such as generosity, altruism, desire for fairness, and the "warm glow" stemming from privately contributing to a public good [Fischbacher U. et al. 2015, Blasch J. & Ohndorf M. 2015]. Finally, the identification with a group of peers, the desire of social recognition and the preference for local investments or producers may also push in the same direction [Blasch J. et al 2017, Salm S. et al 2016].

3. Methodology

The method we chose is a DC experiment on stated preferences collected via a web-based survey.

DC analysis is a descriptive and operational theory of human behaviour that assumes that the decision maker, when faced with a set of mutually exclusive and collectively exhaustive alternatives, selects the alternative that provides him with the highest indirect utility. The utility the decision maker extracts from each alternative depends on the alternative's features, the so-called "attributes", rather than from the consumption of the alternative itself, and may as well be influenced by the decision maker's demographic characteristics, attitudes, and beliefs. Product attributes and the decision maker's demographic, behavioural and attitudinal characteristics build up the observable, systematic component of the decision maker's utility function, that also includes an unobservable, random component.

DC analysis is particularly useful in our case, as it allows to:

- Evaluate trade-offs across different attributes of the alternatives,
- Assess both the WTP for improving service quality with respect to actual levels, and the willingness-to-accept (WTA) a compensation for a reduction in the service quality, thus accounting for possible WTP/WTA discrepancies arising from endowment effect and status quo biases, as suggested by Kahnemann and Twersky.

Moreover, by applying DC analysis on stated preferences, we are able to include in the model types of electricity supply contracts and attribute levels that are not available yet on the (Swiss) market, due to technological or legal constraints.

4. The discrete choice experiment

We performed the DC experiment by means of a web-based survey. The survey included:

- Questions regarding demographic variables selected based on the above-mentioned literature: gender, age, nationality, education, region of residence, working status, monthly household income, type of dwelling, environmental friendly facilities adopted in the household, number and age of the people living in the house, amount of the electricity bill and whether the bill included a fixed share of guaranteed renewable electricity, energy saving and energy-related habits in daily life, experience of a long or short blackout at home or at work in the last 12 months. Descriptive statistics and a comparison with the available figures for the Swiss population are available in Tables 5, 6 and 7 in the Annex,

- A set of 30 attitudinal statements, on which respondents where asked to state their agreement or disagreement on a 7-points Likert scale. The topics covered include attitudes toward: nuclear, coal- and gas-fired generation, the use of renewable energy sources for generating electricity, local impacts of wind generation, electricity imports, blackouts, increases in electricity prices, climate change, and environmental pollution,
- Seven choice tasks, where consumers had to choose one out of five alternative electricity supply contracts for their own dwelling. The contracts differed by the following attributes:
    - A label corresponding to the kind of primary energy source used (nuclear energy, hydroelectric energy, wind, sun, and an unspecified energy mix with a variable contribution from unspecified renewable energy sources),
    - The price of electricity in CHF cent/kWh,
    - The number of short blackouts per year (a short blackouts is defined as a complete interruption in electricity supplies lasting 5 minutes),
    - The number of long blackouts per year (a long blackouts is defined as a complete interruption in electricity supplies lasting 4 hours).

The attribute levels, described in Table 1, were defined based on the average values observed in Switzerland in the past few years[5], the variance observed across alternative suppliers and electricity contracts within the same country, and the experiences of other European countries with different energy systems. The respondents were made aware of the average levels observed in Switzerland by means of a short introductory text before the choice experiment.

Table 1 – Alternatives, attributes and attribute levels in the DC experiment

<table>
<tr><td></td><td></td><td colspan="5">Alternatives</td></tr>
<tr><td></td><td></td><td>Nuclear</td><td>Mix</td><td>Hydroelectric</td><td>Sun</td><td>Wind</td></tr>
<tr><td rowspan="4">Attributes</td><td>Price (CHF cent/kWh)</td><td>14.5, 18, 21, 24, 27.5, 50</td><td>14.5, 18, 21, 24, 27.5, 50</td><td>18, 21, 24, 27.5, 50</td><td>21, 24 ,27.5, 50</td><td>18, 21, 24, 27.5, 50</td></tr>
<tr><td>Nr of 5-minute-long blackouts per year</td><td colspan="5">0, 0.25, 1, 4</td></tr>
<tr><td>Nr of 4-hours-long blackouts per year</td><td colspan="5">0, 0.25, 1, 4</td></tr>
<tr><td>% of electricity from renewable energy sources</td><td></td><td>40, 60, 80, 100</td><td></td><td></td><td></td></tr>
</table>

[5] The average levels observed in Switzerland at the time of the survey were the following:

- Final electricity price for the representative household in 2014: 21 CHF cent/kWh (Elcom),
- Contribution of renewable energy to the national generation mix in 2014: 60% (Swiss Federal Office for Energy),
- Average number of interruptions per year per end consumer (SAIFI) in 2011: 0.41; average duration of interruptions per year per end consumer (SAIDI) in 2011: 29 minutes, with spikes up to 2,5 hours (Elcom).

The choice tasks were defined through efficient design with blocking. The design was obtained as an average of a random parameter and an error component specification, and was corrected with the preliminary estimates resulting from a pilot survey on 10% of the sample.

Between January and February 2015 we collected 1006 validly completed surveys from a stratified sample, representative of the resident population of the French- and German-speaking parts of Switzerland, with a response rate around 37%.

5. Model specification

We specified a hybrid DC model with two latent variables (LV), in order to include in the analysis attitudinal drivers that cannot be directly observed from the respondents, but are derived from their responses to the attitudinal statements.

Following Walker J. L. 2001, the hybrid model is composed by two parts: one for the DC model, and one for the LVs.

The DC part of the hybrid model includes:

- a series of structural equations describing U_{ijt}, the utility that respondent *i* extracts from choosing alternative *j* in choice task *t*, as a function of the alternative attributes Z_j, the respondents' observed demographic variables X_i, the respondent's unobserved LVs variables X^*_l, and a vector of parameters β that will be estimated,
- a measurement equation describing y_{it}, that is respondent *i*'s choice in choice task *t,* as a function of utilities U_{ijt}:

$$U_{ijt} = V_{ij}\left(Z_j, X_i, X_i^*; \beta\right) + \varepsilon_{ijt}\ , \text{ with } \varepsilon_{ijt} \text{ i.i.d.} \sim EV(0, \mu_\varepsilon)$$

$$y_{it} = 1 \text{ if } U_{it} = \max\{U_{ijt}\}\ \forall\, j \in C, \qquad y_{it} = 0 \text{ otherwise}$$

The LV part of the hybrid model includes, for each LV X^*_i:

- one structural equation connecting X^*_i to a set of respondents' observed variables X'_i, and a vector of parameters λ that will be estimated,
- a series of measurement equations, each connecting a selected indicator I_i, corresponding to respondent *i*'s evaluation of a selected the attitudinal statements, to respondent *i*'s unobserved LV X^*_i.

$$X_i^* = h(X'_i; \lambda) + \omega_i, \qquad \omega_i \sim N(0, \Sigma_\omega)$$

$$I_i = m(X_i^*, \alpha) + \nu_i, \qquad \nu_i \sim N(0, \Sigma_\nu)$$

The hybrid choice model is estimated via simulated maximum likelihood. The likelihood function corresponds to the integral of the choice model over the distribution of the latent constructs, as measured through the selected indicators. Thus, assuming that errors ε, ω and ν are independent, the likelihood function takes the following form:

$$L = \int P(y_{it}|Z_j, X_i^*, X_i; \beta, \Sigma_\varepsilon) * f(I_i|X_i^*, \alpha; \Sigma_\nu) * f(X_i^*|X_i, \lambda, \Sigma_\omega) dX_i^*$$

As a term of comparison for the hybrid discrete choice model, we also present the result of a simple multinomial logit (MNL) model. The latter was estimated using the same econometric framework, but excluding LVs and hence the whole LV part of the model.

Both the hybrid, and the MNL models include variables corresponding to the alternatives' attributes:

- Alternative-specific constants for each alternative but *Mix*, that serves as a reference,
- Electricity prices in linear form,
- Percentage increases in the probability of experiencing a short (or long) blackout with respect to the actual level of 0.25 blackouts per year,
- Percentage decrease in the probability of experiencing a short (or long) blackout with respect to the actual level,
- A dummy variable set equal to 1 if the share of renewable energy in the *Mix* alternative is lower than 60%, i.e. the current level,
- A dummy variable set equal to 1 if the share of renewable energy in the *Mix* alternative is higher than the current level.

After testing several specifications of MNL models including demographic and behavioural variables directly provided by each respondent, we began the estimation of the hybrid DC model by studying the respondents' evaluations of the attitudinal statements. This step was needed in order to identify indicators for candidate LVs corresponding to the respondents' attitudes and beliefs that could affect preferences toward the available contracts. Table 2 collects the results of the principal component analysis of the attitudinal statements. The statements displayed in the table are used as indicators in the measurement equations for each candidate LV.

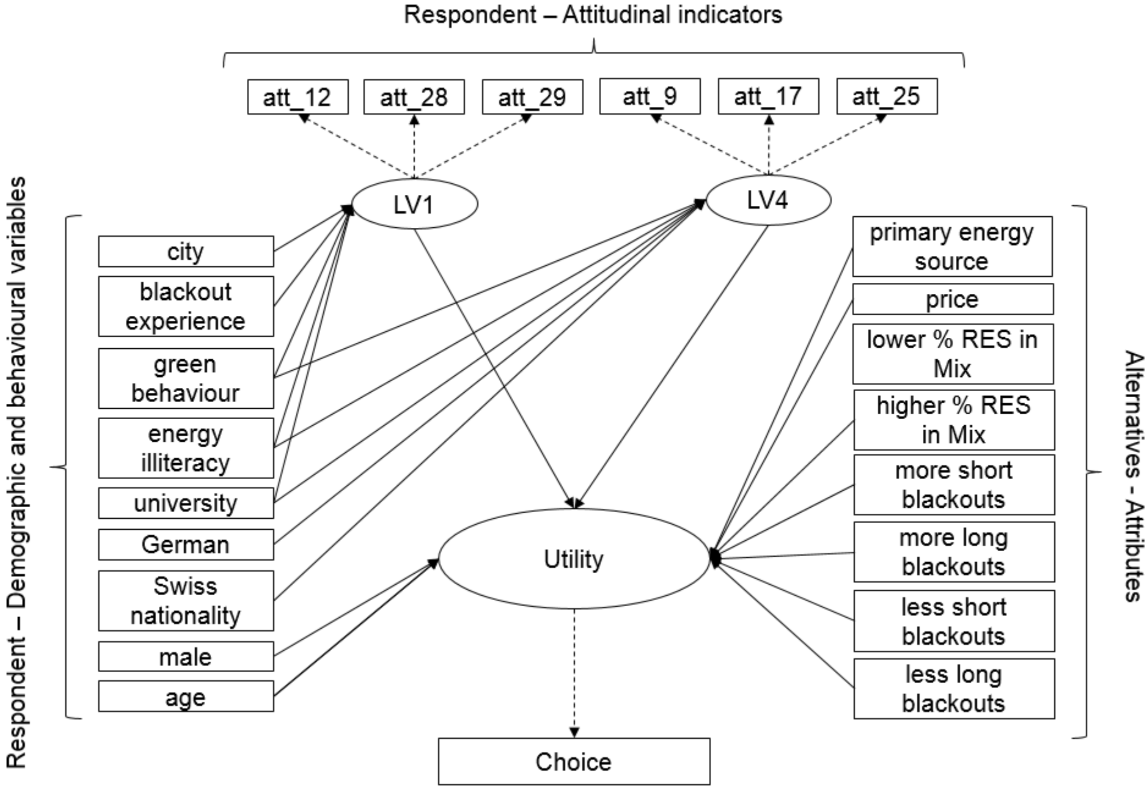
Table 2 – Candidate LVs and relevant indicators

		LV1 "Pro-environmental attitude"	LV2 "Conservative attitude"	LV3 "Pro import attitude"	LV4 "Accepting nuclear and thermal generation"
att_29	I am worried about climate change	0.30			
att_12	I am worried about pollution	0.30			
att_28	Generating electricity via RES is important	0.29			
att_15	Import dependency for electricity supplies endangers our economy		0.33		
att_20	I am frightened when there is a blackout at my place		0.30		
att_6	Blackouts can be costly for households		0.31		
att_7	I am worried about increasing electricity prices		0.31		
att_3	It is safe to import electricity from abroad			0.48	
att_22	I am worried about depending on foreign countries for energy			*-0.35*	
att_27	Electricity can be safely imported from abroad			0.50	
att_9	I think the risk of a nuclear accident in Switzerland is very low				0.32
att_25	It is dangerous to live close to a nuclear generation plant				*-0.40*
att_17	It is dangerous to live close to a gas-fired generation plant				*-0.42*
Proportion of variance		20.8%	10.4%	7.4%	6.7%
Cumulative variance		20.8%	31.1%	38.6%	45.3%
Cronbach Alpha		0.76	0.56	0.73	0.69

We decided to exclude LV2 and LV3 from the model: the former because of its relatively low internal consistency, as measured by the Cronbach Alpha indicator, the latter because of its lower relevance with respect to our focus on primary energy sources. Hence, we focussed on LV1, measuring a strong concern about climate change and pollution and a favourable attitude toward the use of renewables, and LV4, corresponding instead to a positive stance toward nuclear and thermal generation.

Figure 1 describes the final specification of the hybrid choice model: as usual in this literature, ovals contain unobservable variables, whereas rectangles contain observable variables; solid arrows represent structural relationships, while dotted arrows represent measurement equations.

Figure 1 – Hybrid DC model specification



6. Results

The software we used for estimation is PythonBiogeme [Bierlaire M. 2016]. Tables 3 and 4 collect the estimation results of the hybrid choice model and, as a term of comparison, the simple MNL model. Table 3 focusses on the discrete choice part of the hybrid model, whereas Table 4 provides the estimates for the LV part of the hybrid model.

We start the analysis by looking at how respondents evaluate the alternatives' attributes. The results collected in Table 3 suggest what follows:

- In the hybrid model respondents do not show strong ceteris paribus preferences for specific primary energy sources: alternative-specific constants (*ASC_source*) are indeed not significant. This result does not hold in the MNL model, where the alternative-specific constant for the *Nuclear* alternative is strongly negative, witnessing an aversion to this primary energy sources. The reasons behind this discrepancy between MNL and hybrid model will be investigated in the next paragraphs,
- Both models show instead a strong variability in the sensitivity to price increases for each primary energy source: price coefficients (*B_P_source*) differ across alternatives, as confirmed by means of a likelihood ratio test. Price sensitivity is higher for the *Nuclear* and *Wind* alternative, and lower for *Sun* and *Hydro*. Price coefficients show a comparable magnitude in the two models, and also provide a similar ordering of alternatives,

- The coefficients for a further reduction in the frequency of short and long blackouts (*B_sbb* and *B_lbb*) are not significant in both the hybrid, and the MNL model. This result might be due to the fact that the frequency of blackouts is already very low in Switzerland, so that household consumers are, on average, not willing to pay more for higher security levels;
- The coefficients for an increase in the frequency of short and long blackouts (*B_sbw* and *B_lbw*) are instead negative and significant in both models, with the former coefficient approximately equal to one third of the latter. This suggests that household consumers strongly oppose any worsening in the level of security they enjoy at present, and perceive long blackouts as much more annoying than short ones. The hypothesis of a discrepancy between WTP and WTA values is thus confirmed in our analysis,
- The coefficient for a decrease in the contribution of renewable energy sources in the *Mix* alternative (*B_mixless*) is not significant in both models. On the contrary, the coefficient for an increase in the contribution of renewables (*B_mixmore*) is positive and significant in the MNL model, suggesting a positive attitude of respondents toward the provision of a "greener" supply irrespective of the kind of energy source used. *B_mixmore* is instead not significant in the hybrid model.

The discrepancies observed between the hybrid and MNL model as regards the alternative-specific constants and the coefficients for a higher share of renewables in the *Mix* alternative can be explained by looking at the impact of the additional demographic and attitudinal variables included in the hybrid model.

LV1, corresponding to a stronger pro-environmental attitude, is included in the utility functions of the *Sun*, *Wind*, and *Hydro* alternatives (coefficient *B_LV1res*). LV1 also enters the utility function for the *Mix* alternative, both as a main effect (coefficient *B_LV1mix*), and in an interaction with the dummy variable corresponding to an increase in the share of renewables (coefficient *B_LV1resmixmore*). The estimation results collected in Table 3 show that LV1 has no significant effect on the probability of preferring a specific renewable energy source or the *Mix* alternative over *Nuclear*: indeed, *B_LV1res* and *B_LV1mix* are not significant. The effect of LV1 is however significant and positive in the interaction term in the *Mix* alternative (*B_LV1resmixmore*). This suggests that that although consumers with a stronger environmental attitude do not necessarily prefer a specific primary energy source, they are willing to pay more for having a generically greener supply.

LV4, corresponding to a positive attitude toward nuclear and thermal generation, is instead included in the utility function of the *Nuclear* alternative (coefficient *B_LV4nuc*). Table 3 shows that respondents with a more positive stance toward nuclear and thermal generation are more likely to choose the *Nuclear* alternative, as witnessed by the positive and significant (10% significance level) value of *B_LV4nuc*.

As regards the direct impact on utility of other demographic and behavioural variables:

- An older age is found to have a negative impact on the probability of choosing both a renewable-based alternative (*B_ageres*) and the *Nuclear* alternative (*B_agenuc*). This result suggests that older respondents might be simply less interested in the environmental content of their own electricity supply contract,
- Men were found to be more likely to sign a nuclear-based contract, as measured by the positive and significant coefficient *B_malenuc*. Gender has instead no significant effect on the probability of choosing a renewable-based alternative (*B_maleres*).

Table 3 –Estimation results: MNL model vs hybrid model (DC part)

Estimation report	Multinomial logit	Hybrid model with 2 LVs
Number of draws:	-	1000
Number of estimated parameters:	15	47
Sample size:	1006	1006
Initial log likelihood:	-11334	-31300
Final log likelihood:	-8908	-20282
McFadden adj. R squared:	0.21	0.35

Estimated parameters	Multinomial logit			Hybrid model with 2 LVs		
	Value	Robust Std err	p-value	Value	Robust Std err	p-value
ASC_hydro	-0.083	0.161	0.610	0.010	0.321	0.970
ASC_nuc	-1.060	0.261	0.000	-0.418	0.559	0.450
ASC_sun	-0.358	0.167	0.030	-0.264	0.322	0.410
ASC_wind	0.257	0.168	0.130	0.350	0.320	0.280
B_mixless	0.159	0.215	0.460	0.166	0.216	0.440
B_mixmore	0.505	0.091	0.000	-0.241	0.261	0.360
B_P_hydro	-0.058	0.004	0.000	-0.058	0.004	0.000
B_P_mix	-0.062	0.004	0.000	-0.062	0.004	0.000
B_P_nuc	-0.089	0.012	0.000	-0.092	0.012	0.000
B_P_sun	-0.045	0.004	0.000	-0.045	0.004	0.000
BP_wind	-0.080	0.005	0.000	-0.080	0.005	0.000
B_sbb	-0.036	0.034	0.280	-0.041	0.034	0.230
B_sbw	-0.034	0.003	0.000	-0.034	0.003	0.000
B_lbb	-0.015	0.037	0.680	-0.014	0.037	0.700
B_lbw	-0.106	0.004	0.000	-0.107	0.004	0.000
B_agenuc				-0.015	0.007	0.030
B_ageres				-0.015	0.004	0.000
B_malenuc				0.733	0.187	0.000
B_maleres				0.002	0.097	0.980
B_LV1mix				-0.302	0.266	0.260
B_LV1res				-0.201	0.274	0.460
B_LV1resmixmore				0.146	0.048	0.000
B_LV4nuc				0.564	0.347	0.100

The demographic and behavioural drivers behind the pro-environmental and pro-nuclear attitudes measured by LV1 and LV4 are described in Table 4.

A stronger pro-environmental attitude is positively correlated to:

- *Green behaviour*, a composite variable ranging from 0 to 3, measuring the number of environmental-friendly actions in which the respondent engages in daily life. These actions include switching lights off when not needed, switching heating off at night, and having subscribed an electricity contract with a higher contribution from renewable energy sources.

Rather intuitively, regular engagement in environmental friendly actions is associated to a higher sensitivity to environmental issues,

- *University*, a dummy variable taking value 1 if the respondent has a university title, 0 otherwise. The sign of this coefficient suggests a positive association between higher education and a stronger environmental sensitivity,
- *City*, a dummy variable taking value 1 if the respondent lives in a city, and 0 if the respondent lives in rural areas or the so-called “agglomerations”. The coefficient suggests that urban residents apparently show a higher interest in environmental issues,
- *Has blackout*, a dummy variable taking value 1 if the respondent has reported at least 1 blackout experience at home or in the workplace in the last 12 months,
- *Illiteracy*, an index ranging from 0 to 8 and counting the number of “I don’t know” responses to questions concerning the energy saving appliances or renewable-based devices in the respondent’s own dwelling, and the amount of the own electricity bill. Rather surprisingly, the model suggests that energy illiterate respondents are more likely to show a pro-environmental attitude – and hence to opt for a greener supply, although they are not interested in buying energy from a specific renewable energy source.

A positive stance toward nuclear and thermal generation is instead negatively correlated to:

- *Green behaviour*: this suggests that, in line with the literature concerning the perceived effectiveness of coping behaviour, environmental friendly actions might also be adopted in order reduce the overall productions from energy sources that are perceived as more dangerous or polluting,
- *Illiteracy*: this result could imply that consumers with a deeper interest in energy-related topics might be more aware of the actual risks and trade-offs connected to each available primary energy source, and hence less exposed to instinctive negative reactions toward nuclear and thermal generation, or positive reactions toward renewable energy sources,
- *German*, a dummy variable taking value 1 if the respondent is a German native speaker. This result might be explained by the fact that the German-speaking regions of Switzerland are geographically farther and culturally less close to France than the French-speaking ones. Hence, they are also less exposed to a culture in which nuclear energy has historically played a very important role,
- *University*: this suggests that ceteris paribus, respondents with a university degree are less likely to take a positive stance toward nuclear and thermal generation than the less educated ones,
- *Swiss nationality*: according to our estimates, being a Swiss national has a negative, although almost negligible impact on the probability of showing a positive attitude toward nuclear and thermal generation.

Table 4 – Hybrid model estimation results (LV part)

LV1	Value	Robust Std err	p-value
LV1_city	0.647	0.185	0.000
LV1_green_behav	1.750	0.055	0.000
LV1_hasblackout	0.600	0.141	0.000
LV1_illiteracy	0.515	0.058	0.000
LV1_university	0.995	0.129	0.000
Beta1_att12	0.165	0.027	0.000
Beta1_att28	0.088	0.024	0.000
Inter1_att12	4.990	0.152	0.000
Inter1_att28	5.920	0.131	0.000
Sigma1_star_att12	1.280	0.037	0.000
Sigma1_star_att28	1.030	0.042	0.000
Sigma1_star_att29	1.990	0.044	0.000
LV4	**Value**	**Robust Std err**	**p-value**
LV4_ch	-0.002	0.000	0.000
LV4_german	-0.361	0.220	0.100
LV4_green_behav	-1.350	0.088	0.000
LV4_illiteracy	-0.482	0.064	0.000
LV4_university	-0.182	0.129	0.160
Beta4_att9	0.167	0.051	0.000
Beta4_att25	-0.142	0.061	0.020
Inter4_att9	4.810	0.190	0.000
Inter4_att25	4.100	0.224	0.000
Sigma4_star_att9	1.830	0.028	0.000
Sigma4_star_att17	1.960	0.045	0.000
Sigma4_star_att25	1.910	0.029	0.000

Conclusions

Our analysis sheds some light on the preferences of Swiss households toward specific features of electricity supply, and provides an explanation of the impact that selected attitudinal, behavioural and demographic variables have thereon. The main messages we can draw from our analysis are the following:

- We find that consumers' preferences toward alternative technologies are mainly driven by three factors: a pro-environmental attitude (LV1), a positive stance toward nuclear and thermal generation (LV4), and a varying sensitivity to price increases, with generally lower values for renewable energy sources, with the exception of wind. Gender and age also play a role; more in detail, younger respondents are more sensitive to the kind of energy source used, and women are more likely to oppose nuclear generation,

- According to our estimates, a stronger pro-environmental attitude does not imply a specific preference for a single renewable energy source: environmentally conscious consumers are instead more likely to go for a greener supply irrespective of the renewable energy source used for generation. Given the relatively low price sensitivity observed for the *Mix* alternative, this leaves considerable room to the policy maker (or electricity suppliers) interested in greening the economy (or their own supply portfolio) in the most sensible or cheapest way,
- Environmental consciousness is generally higher in cities and among households with a higher education title; observed pro-environmental behaviours represent a good predictor of a higher environmental consciousness, but energy-literate respondents usually score lower values in LV1,
- On the other hand, we find that a higher energy literacy is generally associated to a more positive attitude toward nuclear and thermal generation. This suggests that providing accurate information may help minimizing or managing opposition to generation technologies that are usually perceived as undesirable for environmental or safety reasons,
- Green behaviours seem to be adopted less often by those respondents who score higher values in LV4. This might suggest that respondents perceive their environmental friendly actions as an effective strategy for reducing "polluting" productions, and hence might be ready to modify their behaviour in order to contribute to the energy transition, for example by engaging in energy saving measures or subscribing green energy contracts.

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Annex

Table 5 – Demographic variables: descriptive statistics for the sample and the Swiss population

Gender	Sample	Population
Man	49.1%	49.5%
Woman	50.9%	50.5%
Age group		
15-29	27.9%	27.3%
30-44	31.1%	32.0%
45-59	33.0%	33.9%
60-64	8.0%	6.8%
Language		
German	73.9%	74.0%
French	26.1%	26.0%
Lives in:		
Stadt + Agglo	79.1%	73.8%
Land	20.9%	26.2%
Nationality		
Swiss	80.4%	75.7%

Table 6 – Demographic variables: descriptive statistics for the sample

Net income per household		Education	
Below 4'000 Fr.	18%	Obligatorische Schule	0%
Between 4'001 and 7'000 Fr.	32%	Haushaltslehrjahr, Handelsschule	2%
Between 7'001 and 8'500 Fr.	11%	Anlehre	1%
Between 8'501 and 10'500 Fr.	13%	Diplommittelschule, allgemeine Schule	3%
Between 10'501 and 16'000 Fr.	11%	Berufslehre	29%
Above 16'000 Fr.	3%	Vollzeitberufsschule	4%
I don't know / No answer	11%	Maturität, Lehrerseminar	9%
Region of residence		Universität, ETH, FH, PH, höhere Berufsausbildung	53%
Westschweiz	25%	**Housing size category**	
Alpen, Voralpen	22%	1 person	47%
Westmittelland	25%	2 people	25%
Ostmittelland	28%	3+ people	28%
Occupation		Missing value	0%
Student	1%	**Kind of housing solution**	
University student	9%		
Apprentice	1%	Rented flat	67%
Housewife / houseman	3%	Rented house	3%
Employee	66%	Own flat	11%
Freelance	4%	Own house	21%
Enterpreneur	5%	More than one	2%
Farmer	0%	**Lives in:**	
Retired	3%	Stadt	51%
Unemployed	4%	Agglo	28%
Other	2%	Land	21%

Table 7 – Energy-related equipment and behavior: descriptive statistics for the sample

Equipment	**Yes**	**I don't know**
Insulating window panes	82%	4%
Insulating walls	62%	15%
Solar heating	11%	5%
Photovoltaic panels	7%	3%
Minergie standard	13%	13%
Other energy saving equipment	21%	26%
Other renewable energy equipment	8%	19%
Behaviour		
Light off when not needed	91%	
Heating off at night	65%	
Renewable electricity contract	44%	38%
In charge of paying electricity bill	81%	
Electricity bill per semester		
Below 200 CHF	25%	
201-400 CHF	38%	
401-800 CHF	13%	
Above 800 CHF	3%	
I don't know		21%
Blackout experience		
Short blackout at home	27%	
Short blackout at work	10%	
Long blackout at home	21%	
Long blackout at work	8%	