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Public preferences for the Swiss electricity system after the nuclear phase-out: A choice experiment

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ABSTRACT

Energy transition towards a sustainable system comprising various energy sources is a major challenge. We conducted a representative survey in the German-speaking part of Switzerland to elicit the population's preferences for electricity from solar, wind or natural gas under different institutional and site-specific conditions. Based on a choice experiment we found a consistent preference for electricity based on solar energy and - to a lesser degree - wind energy, built in existing industrial and commercial areas. We identified five distinct population groups, three of which have a very pronounced profile concerning energy attributes: 'Pro Renewables', 'Pro Switzerland', and 'Pro Landscape'. The largest two groups, 'Moderates' and 'Contra Status Quo' value attributes fairly equally. All groups except Pro Landscape prefer electricity from Switzerland, and all groups except Pro Switzerland accept imports of renewable electricity, preferably from plants operated by Swiss firms. We suggest that unfamiliarity rather than nationalism is at the root of opposition to imports of renewables. An energy mix focusing on renewables and including border-crossing electricity infrastructure could pave the way for a cost-efficient energy transition towards a sustainable and resilient electricity system. Our results show that it would also be publicly acceptable by the majority of the Swiss population.

1. Introduction

Energy transition towards a sustainable system that comprises various energy sources is a major challenge, especially given the large and diverse commercial and political interests involved. Despite the multiple downsides of a continued use of fossil energy, there is an on-going discussion on whether a switch to renewables can outweigh the known disadvantages (Piot, 2014; Energiegesetz-Nein, 2016). Switzerland is currently implementing its Energy Strategy 2050, which aims to (i) reduce energy consumption, (ii) close the four nuclear power plants that currently produce some 35% of Swiss electricity, and (iii) increase the use of renewable electricity, possibly with the use of natural gas as a backup or bridging technology. This has led to the passing of a new federal Energy Law in 2016, upon which opposing politicians promptly started a people's initiative. In 2017, the population voted in a referendum to not overturn this Energy Law, with 58% of voters coming out in favour of the new law (Der Bundesrat, 2017a).

Information on the public opinion concerning a green energy transition can improve decision-making and increase the chance of success and the speed at which such a transition happens. Recent publications have shown that renewable energy is generally supported by the population not only in Switzerland but in many other countries (Visschers and Siegrist, 2014; Truelove, 2012; Rand and Hoen, 2017). However, this support tends to be more on an abstract level than for specific projects (Batel et al., 2013). Actual implementation of renewable energy technologies at the local level is often faced with strong opposition (Bidwell, 2013; Wüstenhagen et al., 2007). Contextual factors, such as institutional and site-specific conditions, therefore have to be taken into account for each specific project (Jobert et al., 2007). This is particularly the case in Switzerland, where people's initiatives can overrule policymakers' decisions on the federal, cantonal and municipal level.

Futhermore, public participation and raising awareness of choices have been recognized as important factors influencing the process of decision-making (Lund, 2000). Therefore, we were interested in finding out which electric energy supply options the population would support under different conditions when having the chance to choose.

Our paper contributes to capturing the human dimension of choosing energy sources, particularly by looking beyond the technological aspects and focusing on people's multifaceted attitudes and decision-making (Sovacool, 2014). We first conduct a literature review to

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properly embed our research questions in the current scientific debate. Then we present the methods used and data collected for our study in section 3, and provide results in section 4. Finally, we discuss our findings and draw conclusions in section 5.

2. Literature review

Many authors have detected a gap between the opportunities provided by new energy sources and technologies on the one side and the actual adoption of such solutions by the broader population on the other (Sovacool et al., 2015; Laird, 2013; Lilliestam and Hanger, 2015; Goulden et al., 2014). Social reluctance with respect to new solutions, which might be based on a low level of information and knowledge (Assefa and Frostell, 2007), could slow the progress needed to achieve a secure energy supply as well as carbon emission reduction goals (Cohen et al., 2014). Recognizing that failure or success of energy transition efforts finally depends on public acceptance (Kasperson and Ram, 2013), it is crucial to elicit the population's preferences, e.g., by focusing on individual-level decision making and context-dependent perceptions and attitudes (Gaede and Rowlands, 2018). Ideally, groups of typical energy users with similar attitudes are to be identified with the aim to predict their behaviour (Stigka et al., 2014). However, simple explanations, e.g., as provided by the NIMBY approach ('not-in-my-backyard'), have frequently been criticized, while calling for a more detailed understanding of the multifaceted public attitudes (Bidwell, 2013). Here, for example, value-driven aspects could play a role, such as taking care of the environment, fairness in planning procedures and governance as well as due process (Demski et al., 2015; Cohen et al., 2014; Horne and Kennedy, 2017; Dimitropoulos and Kontoleon, 2009). Considering such aspects permits to elicit to which extent people might be willing to sacrifice personal utility in favour of an appropriate embedding of new energy solutions. This points to another question, namely whether respondents tend to view alternative energy sources holistically rather than trading off their particular attributes against each other (Rudolf et al., 2014). Here, deeper insights into the relevance of personal, psychological and contextual factors are necessary to explain public support for or rejection of specific energy sources (Devine-Wright, 2007). Jobert et al. (2007) highlight -besides others- landscape impact and ownership as important contextual factors. Several authors have analysed the landscape impact of energy technologies specified, e.g. as external effect on landscape quality, environmental harm or landscape destruction (Bergmann et al., 2006; Ansolabehere, 2007; Scognamiglio, 2016). Concerning ownership relevant aspects for acceptance have been identified, such as local energy autarky (McKenna, 2018) and resource nationalism (Arbatli, 2018).

The fact that the support for the new Swiss Energy Law was strongest in cities and opposition mostly in rural German-speaking areas motivated us to conduct a representative survey in the German-speaking part of Switzerland, primarily interested in the following questions:

1. What are the population's preferences for particular electricity supply options under different conditions?
2. Do identifiable groups within the population support particular electricity supply options?
3. How can differences among these groups be specified?

By answering these questions our study aimed at showing how the preferences of the population can be taken into account, when deciding on future electricity systems (Faiers and Neame, 2006).

3. Methods and data

3.1. Questionnaire components

The questionnaire consisted of four parts. The first part contained a warm-up question to determine the personal attitudes towards different electricity sources in general, i.e., which sources - according to the respondents - should be used to provide Switzerland with electricity in the future. The main part of the questionnaire was a choice experiment to elicit respondents' preferences towards specific contextual attributes of the Swiss energy supply. In a further part of the questionnaire, we assessed the importance of value-driven goals with bearing on the future Swiss electricity system, such as environment and human health, the national economy, energy security as well as procedural and distributional fairness. In the final part, we collected data on respondents' attitudes towards climate change and socio-demographic variables. The latter included information on the political orientation, place of residence (rural vs. urban) and the monthly electricity bill.

3.2. Choice experiment

Choice experiments (CE) are used to elicit what people base their decisions on. They belong to the stated preference methods and allow to determine relative values of attributes considered jointly by the respondents (Alriksson and Öberg, 2008). During the experiment respondents receive a set of different choice tasks, so called choice sets. Within each choice set, respondents choose their preferred option among two or three alternatives, one usually being a status quo or opt-out alternative (Alriksson and Öberg, 2008; Álvarez-Farizo and Hanley, 2002). The choice experiment method is based on random utility theory, which assumes that respondents seek to maximize their utility in choice situations (Alriksson and Öberg, 2008; Louviere et al., 2010). It is assumed that the individual utility depends on different observable attributes, which characterize the options within the choice sets, and an unobservable random component (Alriksson and Öberg, 2008). CE belong to de-compositional methods which means that through the experimental design of the study part-worth utilities of the attributes can be estimated by decomposing respondents' answers (Alriksson and Öberg, 2008).

The advantage of the method is that it can handle choice situations in which several attributes have an influence on a choice and where respondents have to make trade-offs between different attributes (Alriksson and Öberg, 2008; Tabi and Wüstenhagen, 2017). Moreover, in contrast to common survey methods, preferences are indirectly measured, which can reduce the bias of strategic responses (Rudolf et al., 2014; Tabi and Wüstenhagen, 2017). Compared to common rating or rankings of individual aspects, respondents are faced with more realistic situations (Rudolf et al., 2014).

In our choice experiment, people were asked to pick one of three different options for the substitution of Swiss nuclear electricity. The choice task had to be done repeatedly, while two of the options varied for each choice. The third option was always to keep the status quo.

The attributes and levels of the choice experiment are presented in Table 1. They comprise institutional, site-specific and economic factors, and were defined based on expert knowledge and a review of the existing choice experiment literature related to the acceptance of renewable energy and preferences for the configuration of future electricity systems (e.g. Klinglmair et al., 2015; Rudolf et al., 2014; Tabi and Wüstenhagen, 2017). Before starting the choice experiment, all attributes and levels have been explained to the respondents in detail (incl. information on the possible landscape impact of different energy facilities and a description of specific facility locations in neighboring and distant countries).

The first two attributes, *electricity source* and *location of electricity production*, reflect scenarios inspired by the Swiss Energy Perspectives 2050 (BFE, 2013). They feature an almost exclusively renewable electricity system (hydro, solar and wind) or renewables (solar and wind) combined with electricity generated by gas-fired power plants, with the renewable electricity produced mainly inside Switzerland or imported from abroad. For a detailed description of the scenarios see Díaz Redondo et al. (2017).

Table 1
Attributes and levels of the choice experiment.

Attributes	Description	Levels
Electricity source	The electricity could either be produced by photovoltaic power stations, wind turbines or gas-fired power plants.	Solar energy/ Wind energy/ Natural gas
Location of electricity production	Electricity could be produced in Switzerland, neighboring countries or distant countries.	Switzerland/ neighboring countries/ distant countries
Operator of the plants	The operator of the plant could either be a Swiss or a non-Swiss enterprise.	Swiss enterprise/ foreign enterprise
Landscape impact	Depending on the size, facilities that produce electricity can have different impacts on the visual quality of the landscape.	Small impact/ strong impact
Increase of monthly electricity bill	Additional costs of options per household	+10 CHF/+ 15 CHF/+ 20 CHF

The three levels of the attribute *location of electricity production* represent geographical distance of electricity production facilities from Switzerland, as the electricity can be generated domestically, imported from neighboring countries (e.g. wind power from the North Sea) or from distant countries (e.g. solar electricity from North-Africa).

The third attribute, *operator of the plant*, refers to the contextual factor ownership and describes whether a power plant is operated by a Swiss or a foreign company. Together with the attribute *location of electricity production*, this determines the degree of “Swissness” of the different alternatives within the choice experiment. This was inspired by the strong emphasis on the Swiss origin of many products in marketing, and regular popular initiatives to bolster Swiss independence (Bundeskanzlei, 2018). The attribute *operator of the plant* was designed to find out in how far Swiss or non-Swiss control over electricity production (e.g., by a majority of foreign investors) influences the acceptance of domestic or foreign energy production.

The attribute *landscape impact* is a further contextual factor and describes the impact of production facilities on the visual landscape quality. The purpose of this attribute was to get respondents to make trade-offs between domestic electricity production and conservation of the domestic landscape. Furthermore, we were interested in finding out, whether respondents care about landscape impacts when the impacts are outside their home country.

Finally, we included a *cost* attribute, which was operationalized as an increase in the monthly electricity bill, following Díaz Redondo et al. (2017). We have chosen a stepwise increase small enough to be realistic (compared to the average monthly electricity bill per household) and big enough to detect statistically significant differences.

The choice experiment is based on a D-efficient design generated by the software Ngene (ChoiceMetrics, 2014). The parameters have been effects-coded to estimate the impact of specific attribute levels on utility instead of using just one single parameter for each attribute. The opt-out alternative describes the status quo of electricity production in Switzerland. The current Swiss electricity supply consists of around 60% hydropower that will remain indefinitely, 35% nuclear that will be phased out, and other sources including municipal waste, natural gas, solar photovoltaic (PV), wind, and biomass. Switzerland exports surplus electricity in summer and imports in winter, and its grid also carries foreign exports, mainly to Italy (BFE, 2018). The opt-out choice states that the current electricity mix should be maintained as long as possible, and it was included so that people are not forced to make a decision on how to replace the nuclear share in the electricity system.

We conducted a pre-test based on 32 completed questionnaires. A special focus was put on controlling the length of the survey and the comprehensibility of the choice tasks. Based on the results and feedback of the pre-test, we used the estimated prior values of the attribute coefficients to improve the model design, while reducing the number of choice sets to 12 instead of 18 to avoid respondents fatigue (see Fig. 1 for an example of the choice stets).

3.3. Sample

We programmed the online questionnaire using the software package Sawtooth. The data was collected in June and July 2017 using a household panel administered by a professional market research institute,[1] which was responsible for distributing invitations with a link to the survey. The questionnaire was conducted in the German-speaking part of Switzerland, which comprises about 63% of the overall permanent residential population. We applied a soft quota in order to have a sample that is representative in terms of age, gender and education for the total Swiss population. The response rate was 19.7% and a total of $n = 1{,}282$ respondents completed the questionnaire. 96 respondents were excluded as “speeders” and “click-throughs”. The cut-off time was set at 7 min, which reflects less than half the median time needed to fill in the survey. The data of the remaining respondents ($n = 1{,}186$) was used for the final analysis. As can be seen in Table 2 the sample was representative for the total Swiss population in terms of gender, age and education. The mean age of all respondents in the sample was 48 years. The share of urban and rural respondents was 61% and 39%, respectively.

3.4. Data analysis

We used the Sawtooth Lighthouse Studio 9.3.1 software to estimate choice models. In a first step, we estimated a (main-effects) multinominal logit model (MNL), which is the basic and most widely used way to analyse data from discrete choice experiments (Klinglmair et al., 2015, Olschewski, 2013). However, simple MNL models do not account for heterogeneity of people's preferences (Klinglmair et al., 2015; Strazzera et al., 2012). Therefore, other methods have been proposed to estimate choice models comprising mixed logit models (MLX), latent class models (LCM) and hierarchical Bayes estimations (HB) (Klinglmair et al., 2015; Strazzera et al., 2012; Tabi and Wüstenhagen, 2017). As we were looking for groups of people with similar preferences for energy supply options, we used a latent class model to analyse the data.

After defining the distinct preference groups based on the LCM, we analysed which source of electricity and which operator the different LCM groups prefer for each location. We therefore calculated separate MNL models for the different latent class groups with the interaction terms ‘*source*location*’ and ‘*location*operator*’ and checked if the MNL models with interaction terms fit the data significantly better than a simple MNL per group without interactions. We then calculated the utilities of the interactions between two attribute levels as the sum of the utility of each attribute level and the utility of the interaction term (Chrzan and Orme, 2017). In those cases where the fit with interaction term in the model was worse than without, we calculated the combined utilities of two levels of different attributes without the interaction

[1] For more information see http://www.bilendi.de.

	If these were the only options you have, which one would you choose?		
	Option 1	***Option 2***	***I choose none of these options***
Electricity source	Natural gas	Solar energy	The current electricity mix (approx. ca. 60% hydro and 35% nuclear energy) will be maintained as long as possible
Location of electricity production	Switzerland	Neighbouring countries	
Operator of the plants	Swiss enterpise	Foreign enterprise	The plants will be operated by Swiss enterprises
Landscape impact	small	strong	Landscape will not change for now by new production plants
Increase of monthly electricity bill	+ 10 CHF	+ 20 CHF	The monthly electricity bill will not change for now
My choice:			

Fig. 1. Example of a choice set.

Table 2
Gender, age and education of respondents compared to the Swiss population. * Sources: BFS (2018a,b).

	Sample (n = 1186)	Sample (in %)	Total population (CH, in %) *	Deviation
Gender				
Male	580	48.90%	49.49%	0.59%
Female	606	51.10%	50.51%	−0.59%
Age				
18–19 years	33	2.80%	3.10%	0.30%
20–29 years	224	18.90%	18.05%	−0.85%
30–39 years	226	19.10%	19.97%	0.87%
40–49 years	255	21.50%	21.26%	−0.24%
50–59 years	247	20.80%	20.81%	0.01%
60–70 years	201	16.90%	16.80%	−0.10%
Education				
Primary level	149	12.60%	12.60%	0.00%
Secondary level	579	48.80%	46.20%	- 2.60%
Tertiary level	447	37.70%	41.30%	3.60%

term.

In a final step, we analysed the items from 18 survey questions that pointed at value-driven goals for the electricity system by applying a Principal Component Analysis (PCA) using the software SPSS. All items were preceded by the question "When it comes to the future electricity supply of Switzerland, how important is it to you that … ?" (1 = not important at all, 7 = very important). We developed a scale that elicits value-driven goals based on former research on (public) values related to the energy system, renewable energy, and climate change mitigation (Demski et al., 2015; Visschers and Siegrist, 2014), and a yet unpublished work by Demski et al. (2017, personal communication). The scale has been tailored specifically to electricity production and considers goals on several dimensions. Inspection of the correlation matrix showed that all variables but one had correlation coefficients greater than 0.3. As a result, the respective item ("… that electricity supply is reliable no matter how the electricity is produced") was excluded from the analysis (Field, 2009). The Kaiser-Meyer-Olkin (KMO) measure for the final PCA was 0.92, indicating very good sampling adequacy (Field, 2009). Bartlett's test of sphericity was statistically significant ($p < .005$), indicating that the data was likely factorizable. The resulting PCA allowed us to group several variables to a reduced number of components that measure the same construct.

4. Results

4.1. Determination of preferences for particular electricity sources

We calculated attribute importance from the distance between the most and least preferred level of an attribute. This value is then divided by the sum of distances of all attributes. The importance of the respective attributes is expressed as percentage share, adding up to 100% for all attributes (Table 3) (Sawtooth Software, 2017; Tabi and Wüstenhagen, 2017).

We found that the *electricity source* is the most important attribute for people's choices. The second most important attributes are the *operator of the plants* and the *increase in the monthly electricity bill*. The third most important attribute is the *location of the plant*. However, the attributes *location*, *operator* and *increase in monthly electricity bill* are almost equally important for people's choices. By far the least important attribute is the impact of the power facilities on the *visual landscape quality*.

The results of the MNL model are presented in Table 4. The χ^2-statistic shows that the estimated MNL is significantly better than the null-model. The root-likelihood (RLH) value is a measure of how well the model fits the data. It can range between the reciprocal of the number of alternatives available in the choice tasks and 1, with 1 indicating a very good model fit (Sawtooth Software, 2017). In our choice experiment we had three alternatives, therefore the lowest possible RLH is 0.33. The RLH of the MNL model is 0.36, indicating a rather poor overall model fit. However, given that all attributes have a significant impact on respondents' utility, we proceeded with this basic model, stepwise extending it by taking latent classes and interactions of attributes into account. For the *electricity source*, solar electricity has the highest utility for respondents when compared to wind energy and

Table 3
Attribute importance (Multinominal Logit Model, total sample).

Attribute	Attribute Importance
Electricity source	30
Location of electricity production	20
Operator of the plants	22
Landscape impact	6
Increase in monthly electricity bill	22

Table 4
Multinominal logit model.

	Effect	Std Error	t-ratio	Utilities (zero-centered differences)
Electricity source				
Solar energy		0.380.02	18.23	58.93
Wind energy		0.220.02	12.72	34.15
Natural gas		−0.590.03	−22.62	−93.08
Location of electricity production				
Switzerland		0.320.02	18.42	49.76
Neighboring countries		0.000.02	0.22	0.58
Distant countries		−0.320.02	−16.41	−50.34
Operator of the plants				
Swiss enterprise		0.350.01	30.69	54.80
Foreign enterprise		−0.350.01	−30.69	−54.80
Landscape impact				
Small impact		0.090.01	7.17	14.81
Strong impact		−0.090.01	−7.17	−14.81
Increase in monthly electricity bill				
+10 CHF		0.260.02	15.83	40.60
+15 CHF		0.180.02	10.41	27.46
+20 CHF		−0.430.02	−24.73	−68.06
Opt-out option		−0.210.02	−10.51	−32.25
Choice observations	14232			
Individuals	1186			
RLH	0.36			
Log likelihood	−14557			
Log Likelihood Null model	−15635			
χ^2 (*p*-value < .001)	2155			
AIC	29133			
BIC	29201			

natural gas. For the *location* where electricity is produced, Switzerland is the preferred location and also Swiss plant operators are preferred.

Interestingly, an increase from 10 to 15 CHF of the monthly electricity bill is not seen a major obstacle to renewable energy expansion, while an increase to 20 CHF/month, as the highest level of the cost attribute, has a significant negative impact.

4.2. Analysis of groups supporting particular electricity supply options

4.2.1. Identifying population groups

To account for individual differences in people's preferences, we applied a latent class model (LCM). We used a main-effects model as it is suitable to capture the main information about different preferences of respondents (Sawtooth Software, 2004). Table 5 shows the LCM statistics for different numbers of groups. Based on the Likelihood ratio as well as the Akaike and Bayesian Information Criterion (AIC and BIC) we chose our final model with five classes (groups). We developed a characterization of the five latent class groups in Table 6.

Fig. 2 shows the relative attribute importance per latent class (LC) group. The detailed results of the five-class model are presented in Table 7.

4.2.2. Determining group preferences

For all latent class groups the MNL model with interaction terms was significantly better than without, except for group 2 and group 5 (see Appendix: Tables 12–16). We therefore included only the interaction terms '*location*operator*' for group 2 and no interaction terms for group 5 in the further analyses (see Appendix: Tables 13 and 16). The preferences for the different electricity sources (solar energy, wind energy and natural gas) in different locations (Switzerland, neighboring countries and distant countries) for each of the groups of the latent class analysis are depicted in Fig. 3.

Based on the overall MNL and LC models, and MNL models with interactions, we find two patterns: The first is that renewables are generally preferred by four of the five groups, and PV is preferred overall. Second is that electricity production closer to Switzerland is generally preferred. The smallest group, Pro Landscape, are the exception on these two patterns. Upon examining the interaction of *location of electricity production* and *operator of the plant* for all groups, a third pattern emerges: that Swiss plant operators are preferred in Switzerland as well as in neighboring countries. We summarise these patterns and those from the following analyses in Table 11.

Table 5
Statistics for latent class models with different numbers of groups.

No. of groups	No. of parameters	Log-likelihood	AIC	BIC	Pseudo R^2
2	9	−11890	23818	23962	0.240
3	9	−11418	22894	23114	0.270
4	9	−11055	22188	22483	0.293
5	9	−10918	21934	22305	0.302

4.3. Specification of differences among groups

To characterize the different groups further, we analysed whether the latent class groups differ with regard to socio-demographic variables and the values related to future electricity production. The results are summarised in Table 8.

4.3.1. Analysing socio-demographic characteristics

Our analysis of respondents' age shows that respondents in group Pro Switzerland are significantly older than the respondents in other groups. We also find that there is a significant but weak association between gender and LC group membership, and that respondents do not differ significantly in their level of education.

Related to *political orientation* we used a left-right self-placement scale (Breyer, 2015), and found significant differences between the groups with Pro Renewables being the most left-oriented group, followed by Contra Status Quo and Pro Landscape. Pro Switzerland is the most right-oriented group and Moderates are located rather in the middle of this scale. We found no significant difference between *rural and urban* respondents, neither for Pro Switzerland, where we expected some difference based on the referendum results. In addition, we analysed if the preference groups differ in their *perception of climate change* and found significant differences. Pro Switzerland has significantly less the feeling that climate change is taking place and is also less worried about climate change than all other groups. Furthermore, Pro Renewables has significantly more the impression that climate change is taking place and is also more worried about climate change than Moderates.

4.3.2. Considering value-driven goals for future electricity systems

Based on the data of 18 further survey questions, PCA revealed three components that cluster specific items and explain about 59% of the total variance. A varimax orthogonal rotation was used to support interpretability. Component scores were retained for further analysis, while component loadings of the rotated solution are shown in Table 9.

"Avoiding negative impacts on humans and the environment" (component 1) explains approx. 38% of the variance. People scoring higher values on this component express that the goal for the future electricity production is to only have small negative impacts on humans and the environment.

"Avoiding negative impacts on the national economy" (component 2; 15% of variance) clusters items that refer to the costs and impacts of the future electricity production on the national (Swiss) economy. Respondents who scored high on this component express that the future electricity production should not harm the national economy and that an increase in the electricity costs should be avoided. Further, the item referring to the impact of electricity production facilities on the landscape loads on this factor. This might be due to the fact that the Swiss landscape is seen as an important resource for tourism.

"Realizing fairness, participation and independence" (component 3;

Table 6
Choice preferences of the identified latent class groups.

Latent class group	Preferences
"Pro Renewables" (n = 207):	Source of electricity is by far the most important attribute. Strongly emphasises source of electricity overall, but has very low preference for gas. This group also strongly dislikes the (nuclear) status quo.
"Pro Switzerland" (n = 195):	Location and operator of the plants are the most important attributes. Emphasises location of production and operator of the plant, preferring both to be Swiss, and has a strong preference for the (nuclear) status quo.
"Moderates" (n = 308):	Source of electricity and costs are the most important attributes. Emphasises source of electricity and location of production, disliking natural gas and a strong rise in electricity bills.
"Contra Status Quo" (n = 411):	All attributes except landscape impact are equally important. Emphasises location of production, operator of the plant, source, and increase in monthly electricity bill, and strongly dislikes the (nuclear) status quo.
"Pro Landscape" (n = 65):	Landscape impact is the most important attribute, followed by costs. Strongly emphasises landscape impact and costs. It is the only group that (i) prefers wind over solar as a source of electricity and (ii) prefers renewable sources located in neighboring countries, followed by distant countries. This group also strongly dislikes the (nuclear) status quo.

6% of variance) clusters items that are related to procedural and distributional fairness as well as the independence of the electricity supply from other countries. A high score on this component means that the respective aspects are desired characteristics of the future electricity system.

Furthermore, we conducted a one-way ANOVA to determine whether the five latent class groups differ in respect to how much importance they give to the three components reflecting the value-driven goals for the future electricity supply. We found that latent class groups differed significantly on all components. We explored this further using Games-Howell post-hoc analysis, which is used when group variances are not equal and group sizes vary (Field, 2009). For all three components, Pro Renewables and Pro Switzerland show most differences in goals for the future electricity system, while Pro Switzerland and Moderates are clearly valuing the protection of humans and the environment less than Pro Renewables, Contra Status Quo, and Pro Landscape. The results are summarised in Fig. 4.

4.3.3. Assessing group differences regarding the acceptance of energy infrastructure

Finally our survey comprised specific questions on contextual factors related to the energy infrastructure (answers with a scale from 1 = don't agree at all to 7 = totally agree; compare Table 10). In the total sample, mean disturbance of ground-mounted PV in remote alpine areas is relatively low (M = 3.43). However, significant differences show up between Pro Renewables and Pro Landscape, with the latter being more disturbed by ground-mounted PV plants in remote alpine areas. We also assessed if ground-mounted PV stations near industrial areas would bother respondents. It appeared that these PV stations would disturb respondents less than those in remote alpine areas (M = 2.61), without significant differences among groups.

Furthermore, we asked respondents in how far they would be disturbed by wind turbines in their living environment, in recreation areas as well as in ski resorts and areas used for active outdoor recreation (mountain biking, climbing etc.). For the total sample, we found that wind turbines would disturb most in recreation areas and the living environment, followed by areas used for active outdoor recreation, while bothering least in ski resorts. In addition, there were significant differences between groups, with e.g., Pro Renewables and Contra Status Quo being significantly less disturbed by wind turbines in recreational areas than all other groups.

We also found a slight acceptance of high-voltage powerlines in the living environment with significant differences among groups: Pro Renewables would accept these powerlines significantly more than group Pro Switzerland. Furthermore, the Contra Status Quo group would accept them more than Pro Switzerland and Moderates. The total sample found building high-voltage powerlines abroad to supply Switzerland with renewable energy rather problematic (Table 10)

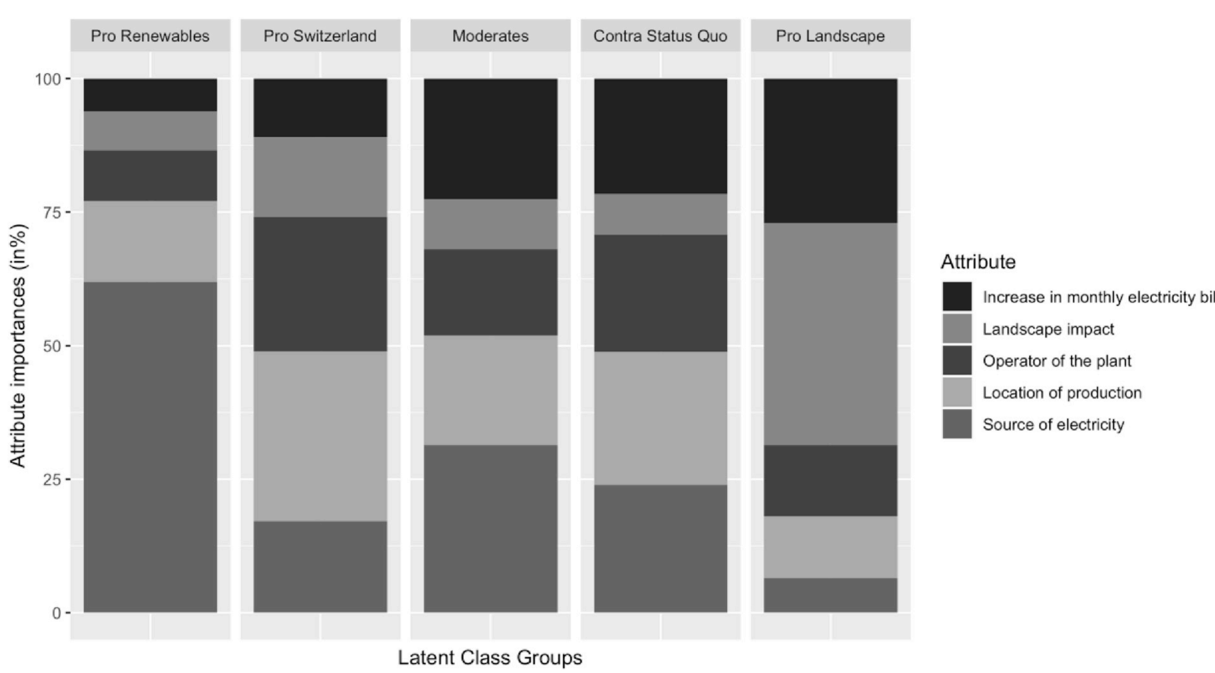

Fig. 2. Attribute importances for the five different latent class groups.

Table 7
Latent class Model (5 classes).

Variable	Part-worth utilities				
	Pro Renewables (n = 207)	Pro Switzerland (n = 195)	Moderates (n = 308)	Contra Status Quo (n = 411)	Pro Landscape (n = 65)
Electricity source					
Solar energy	**1.85** (0.10)	0.74 (0.14)	0.67 (0.04)	0.39 (0.07)	−0.07 (0.20)
Wind energy	**1.22** (0.06)	−0.04 (0.10)	0.31 (0.04)	0.27 (0.04)	**0.30** (0.14)
Natural gas	**−3.07** (0.14)	−0.70 (0.15)	**−0.98** (0.05)	−0.66 (0.11)	−0.23 (0.19)
Location of electricity production					
Switzerland	0.56 (0.07)	**1.47** (0.13)	**0.56** (0.04)	**0.55** (0.05)	−0.54 (0.17)
Neighboring countries	0.08 (0.04)	−0.28 (0.13)	−0.04 (0.04)	0.00 (0.03)	**0.42** (0.13)
Distant countries	−0.64 (0.07)	−1.19 (0.19)	−0.52 (0.04)	−0.55 (0.05)	**0.12** (0.14)
Operator of the plants					
Swiss enterprise	0.38 (0.03)	**1.05** (0.09)	0.42 (0.03)	**0.48** (0.02)	0.55 (0.12)
Foreign enterprise	−0.38 (0.03)	−1.05 (0.09)	−0.42 (0.03)	−0.48 (0.02)	−0.55 (0.12)
Landscape impact					
Small impact	0.29 (0.05)	0.63 (0.11)	0.25 (0.03)	0.17 (0.04)	1.72 (0.13)
Strong impact	−0.29 (0.05)	−0.63 (0.11)	−0.25 (0.03)	−0.17 (0.04)	**−1.72** (0.13)
Increase in monthly electricity bill					
+10 CHF	0.25 (0.05)	0.44 (0.10)	0.54 (0.04)	0.38 (0.03)	0.84 (0.14)
+15 CHF	−0.02 (0.05)	0.04 (0.13)	0.10 (0.04)	0.20 (0.03)	0.56 (0.13)
+20 CHF	−0.24 (0.04)	−0.48 (0.12)	**−0.65** (0.04)	**−0.57** (0.03)	**−1.40** (0.17)
Opt-out option	**−3.18** (0.20)	**3.78** (0.14)	0.51 (0.04)	**−3.21** (0.11)	**−1.15** (0.16)
Class size (in %)	17.45	16.44	25.96	34.65	5.48
Average class probabilities	0.18	0.16	0.26	0.34	0.05
Average maximum membership probability	0.95				
Choice observations	14232				
Individuals	1186				
Log likelihood	−10918				
LL (0)	−15635				
Pseudo R^2	0.30				

*** All attributes in all classes significant at the 1%-level. Standard errors in parenthesis (.).

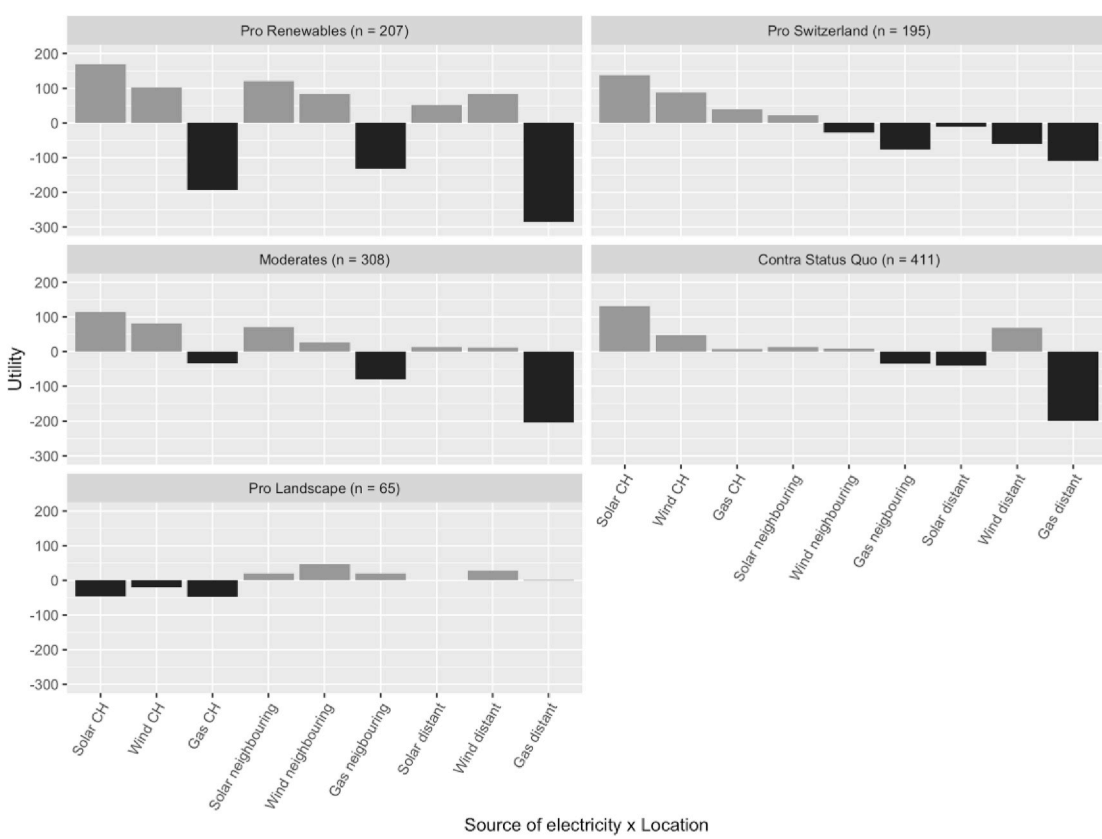

Fig. 3. Utilities for different electricity sources in different locations per latent class group.

Table 8
Summary of socio-demographics of latent class groups.

	Pro Renewables	Pro Switzerland	Moderates	Contra Status Quo	Pro Landscape	Overall test statistic
Age	39.94 [a]	50.69 [b]	42.61 [a]	42.85 [a]	41.80 [a]	F(4,339.47) = 19.08 ***
Political orientation	4.98 [a]	6.21 [b]	5.66 [c]	5.38 [ac]	5.39 [ac]	F(4, 35.63) = 142.51, ***
Climate change perception [b]	5.76	4.63	5.32	5.65	5.41	F(4,43.12) = 172.47, ***
Education (%tertiary education) [a]	39.4 [a]	40.5 [a]	38.8 [a]	35.0 [a]	42.2 [a]	$\chi^2(4) = 2.86$
Rural/urban residents, (% urban)[a]	63.3 [a]	63.4 [a]	60.1 [a]	61.8 [a]	51.6 [a]	$X^2(4) = 3.48$
Gender (% male)[a]	57.5 [a]	52.8 [ab]	49.7 [ab]	44.3 [b]	35.4 [b]	$\chi^2(4) = 15.64$, **

Note: One-way Welch ANOVAs revealed significant differences between latent class groups in respect to socio-demographic variables. Overall test statistics shows Welch's F and significance, with: *p < .05, **p < .01, ***p < .001. Means are reported. Different letters denote the groups that are significantly different from each other at the p > .05 level. Pairwise comparisons were performed using Games-Howell post-hoc test.

[a] For education, gender and the rural-urban divide, a Chi-square test was conducted, indicating the proportion of respondents with a tertiary education, the male proportion for gender and the urban resident proportion. Different letters denote the groups that are significantly different from each other at the p > .05 level. Pairwise comparison were performed using the z-test of two proportions with a Bonferroni correction.

[b] Climate change perception was measured using the items "How concerned are you about human-made climate change?" and asked the level of agreement on the statement "I feel that the climate is changing due to humans". Both items were answered on a 7-point scale from 1 "I do not agree/I am not at all concerned" to 7 "I agree fully/I am very concerned". Cronbach's alpha = 0.84.

though significant differences occur between groups: Pro Renewables find high-voltage powerlines abroad less problematic than Pro Switzerland, Moderates and Contra Status Quo.

Looking at all the previous analyses, we can summarise the preferences and values for each of the five latent lass groups, as shown in Table 11:

5. Conclusion and policy implications

5.1. Renewable energy sources

An advantage of the choice experiment approach is that it allows to better understand the multifaceted preferences of the population (Bidwell, 2013), by not just looking holistically at different energy sources but taking specific attributes and there levels into account (Bessette and Arvai, 2018). Our results show that the source of electricity is indeed the most important component. However, plant ownership and location as well as cost of electricity to the consumers are important contextual factors. In contrast, the impact on the visual quality of landscape played a minor role in our study. We found a consistent and prevailing preference for electricity provision based on solar energy and - to a lesser degree - on wind energy, while natural gas is the least preferred energy option. With respect to the latter, there seem to be no gap between public acceptance and technological feasibility given that recent research has found that natural gas is not needed as a bridging fuel for the energy transition in Switzerland (Díaz

Table 9
Rotated structure matrix for PCA with varimax rotation of a three component questionnaire measuring value-driven goals related to electricity production (n = 1186).

Items	Rotated Component Coefficients		
"Regarding the future electricity supply of Switzerland, how important is it to you that…"?	Component 1 *"Avoiding negative impacts on humans & environment"*	Component 2 *"Avoiding negative impacts on national economy"*	Component 3 *"Realizing fairness, participation and independence"*
… the impacts of electricity production on climate change are low.	**.83**	.12	.10
… the electricity production does not impact the environment.	**.81**	.14	.11
… the electricity production does not generate waste.	**.75**	.15	.15
… the chosen type of electricity supply is non-hazardous for humans and the environment.	**.75**	.02	.38
… future generations will not be burdened with the consequences of our current electricity production.	**.73**	.04	.34
… non-renewable natural resources (e.g. coal, natural gas etc.) are used as little possible.	**.72**	.12	.06
… the impact of the electricity supply on human health is as low as possible.	**.68**	.11	.44
… the Swiss economy is strengthened.	.18	**.77**	.09
… the choice of future energy resources does not affect our prosperity.	.07	**.75**	.07
… higher costs for electricity production are avoided.	-.06	**.73**	.22
… new jobs are created in Switzerland.	.17	**.72**	.13
… the electricity is available to all residents at a reasonable price.	.02	**.53**	.49
… the influence of electricity production on the landscape is as low as possible.	.17	**.49**	.20
… citizens are actively involved in the planning process.	.19	.21	**.70**
… fair and transparent decision-making processes for the planning and construction of production facilities are applied.	.41	.15	**.65**
… the advantages and inconveniences arising from the production of electricity are fairly distributed within society.	.41	.16	**.64**
… the power supply in Switzerland is independent of other countries.	.12	.35	**.55**
Kaiser-Meyer-Olkin (KMO)	.92		
Eigenvalues	6.50	2.48	1.01
% of variance	38.18	14.60	5.96
Cronbach's α	.90	.79	.75

(*Note:* major loadings for each item are in **bold**).

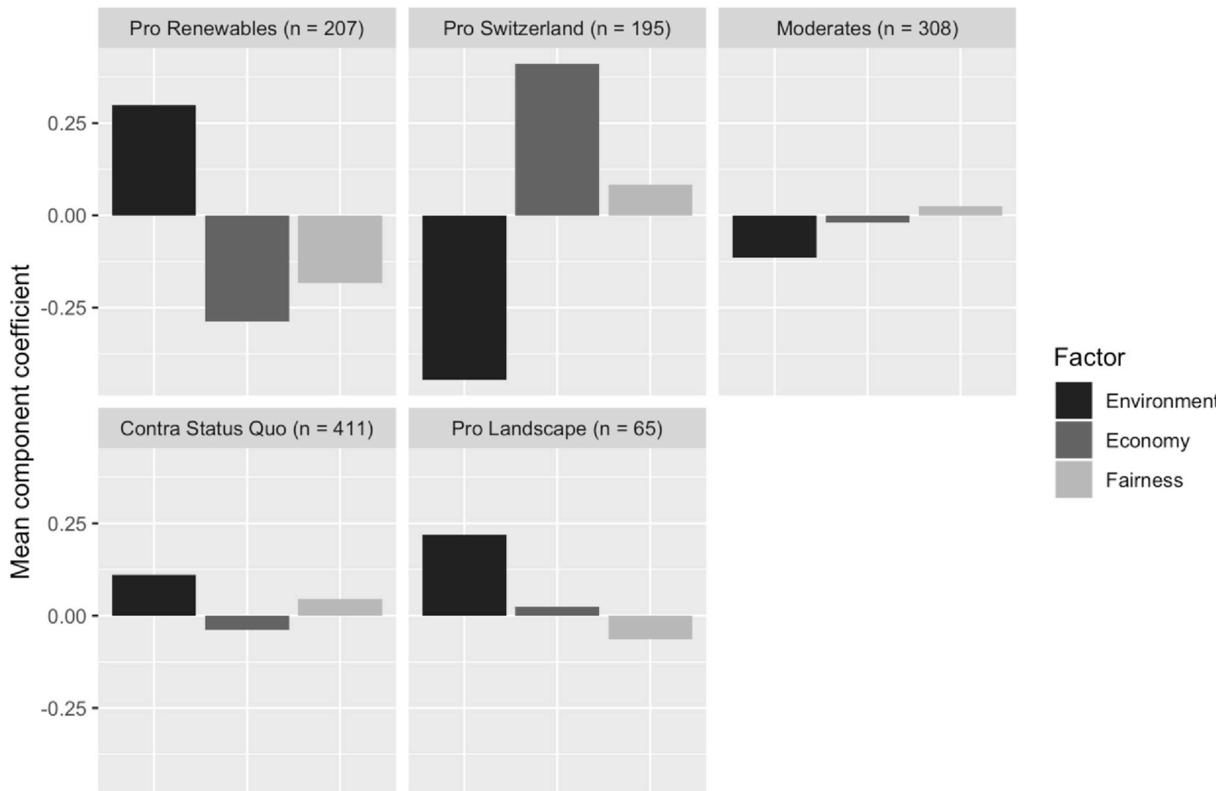

Fig. 4. Differences between latent class groups with respect to value-driven goals.

Redondo et al., 2017). Currently, solar and wind energy contribute only about 1% to the overall Swiss electricity production but their share is foreseen to increase to about 25% in 2050 (Díaz Redondo and van Vliet, 2015). Our representative survey illustrates a high public acceptance of such a scenario, although it has to be noted that there is no automatism from the environmental attitude stated in an experiment to actual intentions to act in an environmental-friendly way (Walter, 2014). However, Stigka et al. (2014) found evidence that people's environmental competence advances along a continuum of "awareness, concern, understanding and action", where perceptions are ultimately followed by actions.

5.2. Location and ownership of energy facilities

Considering the location of renewable energy facilities, we found that the surveyed part of the Swiss population prefers domestic production to electricity imports (Ebers and Wüstenhagen, 2016). This is in line with previous research. Furthermore, several studies detected preferences in favour of regional production (Kalkbrenner et al., 2017; Walter, 2014; Soland et al., 2013). Here, public acceptance can depend on additional factors, such as local ownership patterns, self-sufficiency and energy autarky (Ek and Persson, 2014; Toke, 2018; McKenna, 2018). However, renewable energy projects are often faced with opposition in many other countries (e.g. Upreti and van der Horst, 2004; Pasqualetti, 2011; Batel et al., 2015), and a recent review of studies dealing with preferences for wind energy concludes that people's utility increases with distance to the location of such facilities (Knapp and Ladenburg, 2015). Our survey confirms what Tabi and Wüstenhagen (2017) have found about 'Swissness' being a major factor in Swiss preferences for electricity, most prominently in the Pro Switzerland group. This matches with the broader discourse in Switzerland on independence and economic nationalism (e.g. Federal Department of Foreign Affairs, 2014; Arbatli, 2018), even though Switzerland has imported the majority of its energy for decades (e.g. oil, gas, and nuclear fuel) (BfE, 2017). However, our results suggest that isolationist rhetoric is partly a political convenience, as most of the population also has a positive preference for solar and wind in neighboring countries (see Fig. 2). The social acceptance of such border-crossing electricity infrastructure could pave the way to a cost-efficient energy transition by integrating bigger shares of renewable energy and making the

Table 10
Items used to assess different attitudes related to energy infrastructure.

Items	M	SD	n = 1186 (.) = "don't know"
Ground-mounted PV plants in remote alpine areas that are not suitable for agricultural production would disturb me.	3.43	2.086	1163 (23)
Ground-mounted PV plants near industrial areas would disturb me.	2.61	1.812	1168 (18)
A wind turbine in an area that I use for recreation would disturb me.	4.51	2.026	1129 (57)
A wind turbine in my living environment would disturb me.	4.23	2.091	1144 (42)
A wind turbine in an area that I use for outdoor sports (mountain biking, climbing etc.) would disturb me.	3.62	2.062	1155 (31)
A wind turbine in a ski area would disturb me.	3.36	2.087	1157 (29)
To enable the supply of Swiss renewable energy I would accept a high-voltage power line in my living environment (within a radius of 3 km), if necessary.	4.01	1.965	1119 (67)
I would find the construction of high-voltage powerlines abroad for supplying Switzerland with electricity problematic.	4.63	1.829	1086 (100)
(1 = don't agree at all, 7 = totally agree)			

Table 11
Summary of the main preferences and values of the identified latent class groups.

Latent class group	Preferences and values
"Pro Renewables" (n = 207): source of electricity is by far the most important attribute	Electricity from renewable sources produced in Switzerland but also from abroad are preferred. Maintaining the status quo share of nuclear power in the Swiss electricity system has a strong negative utility, and electricity from gas-fired power plants is also evaluated negatively in all locations. New energy infrastructure is acceptable. The (global) environment is important, but the economy and fairness are not.
"Pro Switzerland" (n = 195): location and operator of the plants are the most important attributes	For this group the most important aspects are that plants are located in Switzerland and that the plant operator is a Swiss company. This group prefers solar and wind electricity produced in Switzerland, followed by electricity coming from gas-fired power plants. Electricity imports are evaluated rather negatively. Maintaining the status quo for nuclear power has a high utility reflecting this group's higher preference for keeping the current system in place. New energy infrastructure is not favoured. Economy is important, but environment is not.
"Moderates" (n = 308): source of electricity and costs are the most important attributes	Renewable electricity from Switzerland is favoured but there are also strong preferences for renewable electricity imports from abroad. Low costs are particularly important to this group. Maintaining the status quo with nuclear power is evaluated slightly positive. This group shows a preference pattern similar to Pro Renewables but with less emphasis on electricity source, and their values suggest that environment is less important than economy and fairness.
"Contra Status Quo" (n = 411): all attributes except landscape impact are equally important	Solar electricity produced in Switzerland is preferred followed by wind power from abroad and wind power produced in Switzerland. Gas in Switzerland is evaluated slightly positively, while maintaining the status quo with nuclear power is evaluated very negatively. Acceptance of energy infrastructure is average. Environment is more important than economy or fairness.
"Pro Landscape" (n = 65): landscape impact is the most important attribute, followed by costs	For this group the landscape impact should be minimized. Renewable electricity imports from abroad are preferred as well as wind power. The highest increase in the monthly electricity bill is strongly opposed. Solar power in Switzerland is evaluated negatively, as is maintaining the status quo with nuclear power. Energy infrastructure is not acceptable, especially in Switzerland. The (local) environment is more important than economy, and fairness is not important.

electricity system more resilient (Puka and Szulecki, 2014).

Our results indicate that respondents' preferences (i) decline for longer distances and (ii) are universally higher for Swiss-operated plants. We suggest that the apparent nationalism is not so much a rejection of foreign renewable energy per se, but more an expression of greater familiarity with and trust in Swiss institutions and companies (Soland et al., 2013). Lienhoop (2018) focused on the distinction between national, regional and local providers and found higher acceptance of local project developers and operators. This is supported by the finding of Oehlmann and Meyerhoff (2017) that higher trust in institutions correlates with increased support for expansion of renewables. This has two important implications for the future of the Swiss energy strategy: The first is that having Swiss enterprises involved in their design, construction, operation, and ownership can make imported electricity politically more acceptable. Conversely, the Swiss take a dim view of foreign companies taking a (controlling) interest in Swiss electricity infrastructure. All of these preferences should be tested in detail in future work. The second is that extending the on-going practice of importing renewable-based electricity will slowly make this as familiar and acceptable as importing oil is today. From an energy security perspective, this can make it easier to balance (i) the need for energy independence (as a means of self-determination to reduce vulnerability to political threats to energy supply) with (ii) the need for diversification of energy sources (as means to reduce vulnerability to natural and technological threats to energy supply) (c.f. Cherp and Jewell, 2011). However, acceptance of imports is by no means guaranteed, as the Swiss population recently voted in favour of a people's initiative on food security that is mostly focused on decreasing food imports (Der Bundesrat, 2017b).

5.3. Population groups

We were able to identify five distinct population groups, three of which have a very specific profile (Pro Renewables, Pro Switzerland, and Pro Landscape), while the other two (Moderates and Contra Status Quo) value attributes fairly equally. While we did not set out to do a political poll, group preferences seem to be related to political orientation. While the Pro Renewables seem oriented more to the left of the political scale, the Pro Switzerland seem oriented more towards the political right. This reflects to some degree party lines, as the right wing party (Swiss People's Party, SVP) initiated the referendum vote on the new energy law and were supported by a minority of the Liberal Party (FDP) (Energiegesetz Nein, 2017; Der Bundesrat, 2017c). The left moreover, including the Social Democratic Party (SP) and the Green Party, are traditionally seen as supporting the expansion of renewable power plants. However, in the case of the energy law, the majority of all other parties in parliament were in favour of the new law (Stalder, 2017). The Moderates and Contra Status Quo, who seem to be oriented towards the centre of the political sphere, therefore potentially reflect this less politicized view.

Moreover, if we assume that nuclear power will definitely be phased out, as planned in the current Swiss policy, the Moderates and Contra Status Quo groups effectively coalesce into a single majority group (719 out of 1186, or 60%). The fact that this group shows less radical preferences could indicate a mix of three possible attitudes: (i) they consider the Swiss energy strategy a good, centrist policy and will continue to support it; (ii) they have not considered the impacts of renewables expansion on their own lives and will move into the other groups as soon as a renewable energy project is discussed or started in their local communities; (iii) they have not given the Swiss energy strategy much thought and could be swayed to greater support or opposition by sufficiently appealing rhetoric.

The intense campaigning in the May 2017 referendum suggests that the third attitude is unlikely (Energiegesetz-Nein, 2016), though we cannot automatically assume that massive campaigning induces the population to spend much thinking on an issue. A lack of awareness and information or disaffection seems to correlate with a preference for familiar or middle-of-the-road options (Assefa and Frostell, 2007). Further work is needed to find out if these preferences are also shallowly held.

Given that we did not include a question on their experience with renewables projects in our questionnaire, it is impossible for us to check the second possibility. However, Pro Landscape shows similarities to the group with strong place attachment found by Strazzera et al. (2012). At the same time, we find no difference in LC group membership between rural and urban respondents. This finding seems to be at odds with the result of the referendum, where support for the new Energy Law was strongest in cities and opposition prevailed in rural areas. We conclude that the voting of the rural population does not just reflect a NIMBY response but that further contextual factors have to be considered to explain this result (see also Bidwell, 2013; Devine-Wright, 2007).

5.4. Shortcomings

One shortcoming of our survey could be seen in the fact that we focused on single energy sources rather than presenting varying energy mixes to fill the gap left by a nuclear phase-out (Stirling, 2010; Rudolf et al., 2014). However, our approach was motivated by historical evidence that socio-technological change is often driven by specific technologies, policies and infrastructures (Braunreiter and Blumer, 2018). Given our aim to extend the empirical evidence regarding preferences for renewable energy sources under different context-specific conditions, we found our approach appropriate, while not overstraining the respondents' cognitive abilities, e.g. during the choice experiment. Furthermore, our comparison of specific electricity options instead of energy mixes is in line with previous research (Bergek and Mignon, 2017; e.g. Klein and Whalley, 2015). Notwithstanding, future research could build on our findings to develop an experiment where respondents choose between different supply mixes. This procedure would be more feasible particularly in countries that are not locked into a dominant share of a single renewable energy source, such as hydropower in Switzerland.

Another shortcoming is that our experiment was almost entirely verbal and this probably did not evoke a reaction as strong as an experiment based on visual representations, especially for landscape impact. Impact on visual landscape quality is often perceived as one of the major opportunity costs of renewable energy projects (Álvarez-Farizo and Hanley, 2002), and is among the most important factors for public opposition to renewable energy projects (Cohen et al., 2014; Cotton and Devine-Wright, 2013; e.g. Scognamiglio, 2016; Wolsink, 2007a; Wolsink, 2007b). In Switzerland, as in many other countries, landscape protection conflicts with the expansion of renewable energy infrastructure because of the anticipated impact on scenic beauty. Therefore, we focused on ground-mounted PV facilities. For rooftop PV, resistance seems even less fierce and, unlike for utility-scale PV, there is anyway no legal way to prevent building owners from installing PV on their property. The International Energy Agency – Photovoltaic Power Systems Programme (IEA-PVPS) estimated that PV on buildings alone can supply sufficient electricity to replace all existing nuclear plants if seasonal storage were not a concern (IEA, 2002; Díaz Redondo et al., 2017). However, considerable overcapacity In Switzerland and beyond would probably be needed to balance and buffer the intermittent production of that much PV energy even when considering the high share of Swiss hydropower. An energy mix that includes imports of, e.g., wind energy from different countries would be more cost-efficient and - according to our results - publicly acceptable by the German-speaking part of the Swiss population (Díaz Redondo et al., 2017; Grams et al., 2017).

We refrained from including landscape visualisations because such impact depends highly on the specific local landscape, and these representations would be hard to generalise (Sheppard, 2005). Furthermore, visualisations would have disturbed the balanced presentation and consideration of the other attributes during our choice experiment. Instead, we framed landscape impact in a more simplistic way following similar, successfully applied approaches (Bergmann et al., 2006; Ku and Yoo, 2010), and included questions on the acceptability of energy infrastructure in a separate section. The respective findings could be used as a basis for developing a range of different landscapes with infrastructure visualisations, such as the visualisations under development in the ENERGYSCAPE project, (Grêt-Regamey, 2018). We assume that a more evocative presentation of renewables in the landscape would lead more respondents to express preferences that match group Pro Landscape, the only group that opposes this solution based on the negative impact on visual landscape quality.

5.5. Final conclusion

Our study aimed at (i) determining the population's preferences for particular electricity options under different conditions, (ii) identifying groups within the population that support particular electricity supply options, and (iii) specifying differences among these groups. Our results show the importance of considering the population's attitudes and decision-making to better understand the public dimensions of energy problems, and contribute to developing "feasible and acceptable solutions" (Sovacool et al., 2015).

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Appendix

Table 12
MNL with the interactions source x location and location x operator for latent class Pro Renewables.

	Effect	Std Error	t-ration	Utilities (zero-centered differences)	Utilities Interaction (zero-centered)
Electricity source					
Solar	1.81	0.14	13.16	113.84	
Wind	1.42	0.12	12.17	89.74	
Natural gas	−3.23	0.23	−13.88	−203.59	
Location of electricity production					
Switzerland	0.42	0.09	4.85	26.28	
Neighboring countries	0.38	0.13	2.87	24.08	
Distant countries	−0.80	0.15	−5.42	−50.36	
Operator of the plant					
Swiss	0.20	0.05	3.74	12.69	
Non-Swiss	−0.20	0.05	−3.74	−12.69	
Landscape impact					
Small impact	0.36	0.13	2.75	22.79	

(*continued on next page*)

Table 12 (*continued*)

	Effect	Std Error	t-ration	Utilities (zero-centered differences)	Utilities Interaction (zero-centered)
Strong impact	−0.36	0.13	−2.75	−22.79	
Increase in monthly electricity bill					
+10 CHF	0.20	0.11	1.85	12.54	
+15 CHF	0.16	0.12	1.26	9.89	
+20 CHF	−0.36	0.15	−2.36	−22.43	
Source x location					
Solar x Switzerland	0.46	0.29	1.59	29.03	169.15
Solar x neighboring countries	−0.27	0.31	−0.85	−16.78	121.15
Solar x distant countries	−0.19	0.24	−0.80	−12.25	51.23
Wind x Switzerland	−0.20	0.19	−1.08	−12.86	103.16
Wind x neighboring countries	−0.48	0.26	−1.83	−30.54	83.29
Wind x distant countries	0.69	0.20	3.37	43.40	82.78
Gas x Switzerland	−0.26	0.25	−1.01	−16.17	−193.48
Gas x neighboring countries	0.75	0.18	4.26	47.32	−132.18
Gas x distant countries	−0.49	0.18	−2.76	−31.16	−285.10
Location x Operator					
Switzerland x Swiss	0.57	0.27	2.13	36.02	74.99
Switzerland x Non-Swiss	−0.57	0.27	−2.13	−36.02	13.58
Neighboring countries x Swiss	−0.19	0.20	−0.94	−11.73	25.05
Neighboring countries x Non-Swiss	0.19	0.20	0.94	11.73	23.12
Distant countries x Swiss	−0.39	0.22	−1.78	−24.29	−61.96
Distant countries x Non-Swiss	0.39	0.22	1.78	24.29	−38.77
Opt-out Option	−2.82	0.19	−15.01	−177.58	
Choice observations	2484				
Individuals	207				
RLH	0.56				
Log likelihood	−1435.70				
Log Likelihood Null model	−2728.95				
χ^2 (*p*-value)	2586.50	(0.001)			
AIC	2901.41				
BIC	2988.67				

Table 13
MNL with the interaction location x operator for latent class group Pro Switzerland.

	Effect	Std Error	t-ration	Utilities (zero-centered differences)	Utilities Interaction (zero-centered)
Electricity source					
Solar	0.81	0.15	5.45	49.34	–
Wind	−0.01	0.11	−0.07	−0.46	–
Natural gas	−0.80	0.16	−5.08	−48.88	–
Location of electricity production					
Switzerland	1.45	0.16	9.09	88.09	–
Neighboring countries	−0.45	0.19	−2.32	−27.41	–
Distant countries	−1.00	0.20	−5.12	−60.68	–
Operator of the plant					
Swiss	0.95	0.13	7.57	57.71	–
Non-Swiss	−0.95	0.13	−7.57	−57.71	–
Landscape impact					
Small impact	0.69	0.12	5.75	41.77	–
Strong impact	−0.69	0.12	−5.75	−41.77	–
Increase in monthly electricity bill					
+10 CHF	0.41	0.11	3.75	24.90	–
+15 CHF	0.07	0.17	0.41	4.24	–
+20 CHF	−0.48	0.14	−3.40	−29.14	
Source x location					
Solar x Switzerland	–	–	–	–	137.43
Solar x neighboring countries	–	–	–	–	21.93
Solar x distant countries	–	–	–	–	−11.34
Wind x Switzerland	–	–	–	–	87.63
Wind x neighboring countries	–	–	–	–	−27.87
Wind x distant countries	–	–	–	–	−61.14
Gas x Switzerland	–	–	–	–	39.21
Gas x neighboring countries	–	–	–	–	−76.29
Gas x distant countries	–	–	–	–	−109.56
Location x Operator					
Switzerland x Swiss	0.24	0.17	1.44	14.82	160.62
Switzerland x Non-Swiss	−0.24	0.17	−1.44	−14.82	15.56
Neighboring countries x Swiss	0.29	0.22	1.35	17.80	48.10
Neighboring countries x Non-Swiss	−0.29	0.22	−1.35	−17.80	−102.92
Distant countries x Swiss	−0.54	0.19	−2.90	−32.62	−35.59
Distant countries x Non-Swiss	0.54	0.19	2.90	32.62	−85.78

(*continued on next page*)

Table 13 (*continued*)

	Effect	Std Error	t-ration	Utilities (zero-centered differences)	Utilities Interaction (zero-centered)
Opt-out Option	3.83	0.15	25.37	232.99	
Choice observations	2340				
Individuals	195				
RLH	0.71				
Log likelihood	−785.36				
Log Likelihood Null model	−2570.75				
χ^2 (*p*-value)	3570.79	(0.000)			
AIC	1592.71				
BIC	1656.05				

Table 14
MNL with the interactions source x location and location x operator for latent class group Moderates.

	Effect	Std Error	t-ration	Utilities (zero-centered differences)	Utilities Interaction (zero-centered)
Electricity source					
Solar	0.79	0.05	15.52	66.10	–
Wind	0.47	0.05	10.18	39.56	–
Natural gas	−1.27	0.08	−16.43	−105.66	–
Location of electricity production					
Switzerland	0.65	0.04	14.77	54.18	–
Neighboring countries	0.06	0.05	1.35	5.40	–
Distant countries	−0.71	0.07	−10.85	−59.57	–
Operator of the plant					
Swiss	0.38	0.03	13.38	31.36	–
Non-Swiss	−0.38	0.03	−13.38	−31.36	–
Landscape impact					
Small impact	0.35	0.05	7.69	29.09	–
Strong impact	−0.35	0.05	−7.69	−29.09	–
Increase in monthly electricity bill					
+10 CHF	0.46	0.05	10.10	38.18	–
+15 CHF	0.21	0.06	3.27	17.22	–
+20 CHF	−0.66	0.06	−10.54	−55.41	–
Source x location					
Solar x Switzerland	−0.07	0.08	−0.85	−5.89	114.38
Solar x neighboring countries	−0.01	0.09	−0.14	−1.00	70.49
Solar x distant countries	0.08	0.09	0.92	6.90	13.42
Wind x Switzerland	−0.15	0.07	−2.21	−12.58	81.16
Wind x neighboring countries	−0.23	0.09	−2.40	−18.93	26.03
Wind x distant countries	0.38	0.10	3.77	31.51	11.49
Gas x Switzerland	0.22	0.09	2.44	18.47	−33.00
Gas x neighboring countries	0.24	0.08	2.99	19.93	−80.33
Gas x distant countries	−0.46	0.12	−3.87	−38.41	−203.64
Location x Operator					
Switzerland x Swiss	0.18	0.06	2.97	14.79	100.34
Switzerland x Non-Swiss	−0.18	0.06	−2.97	−14.79	22.81
Neighboring countries x Swiss	0.12	0.07	1.80	10.41	47.17
Neighboring countries x Non-Swiss	−0.12	0.07	−1.80	−10.41	−36.38
Distant countries x Swiss	−0.30	0.06	−4.88	−25.21	−53.42
Distant countries x Non-Swiss	0.30	0.06	4.88	25.21	−65.73
Opt-out Option	0.60	0.04	13.53	50.44	
Choice observations	3696				
Individuals	308				
RLH	0.39				
Log likelihood	−3524.44				
Log Likelihood Null model	−4060.47				
χ^2 (*p*-value)	1072.05	0.000			
AIC	7078.89				
BIC	7172.11				

Table 15
MNL with the interactions source x location and location x operator for latent class group Contra Status Quo.

	Effect	Std Error	t-ration	Utilities (zero-centered differences)	Utilities Interaction (zero-centered)
Electricity source					
Solar	0.27	0.10	2.66	34.29	–
Wind	0.32	0.07	4.44	41.31	–
Natural gas	−0.59	0.16	−3.66	−75.60	–
Location of electricity production					

(*continued on next page*)

Table 15 (*continued*)

	Effect	Std Error	t-ration	Utilities (zero-centered differences)	Utilities Interaction (zero-centered)
Switzerland	0.48	0.05	9.15	61.51	–
Neighboring countries	−0.04	0.08	−0.47	−4.55	–
Distant countries	−0.44	0.09	−5.18	−56.96	–
Operator of the plant					
Swiss	0.36	0.04	9.47	45.93	–
Non-Swiss	−0.36	0.04	−9.47	−45.93	–
Landscape impact					
Small impact	0.25	0.10	2.61	32.38	–
Strong impact	−0.25	0.10	−2.61	−32.38	–
Increase in monthly electricity bill					
+10 CHF	0.29	0.10	3.08	37.24	–
+15 CHF	0.26	0.10	2.90	33.53	–
+20 CHF	−0.55	0.10	−5.88	−70.77	–
Source x location					
Solar x Switzerland	0.27	0.20	1.39	34.65	130.45
Solar x neighboring countries	−0.13	0.20	−0.79	−16.72	13.02
Solar x distant countries	−0.14	0.20	−0.76	−17.93	−40.61
Wind x Switzerland	−0.44	0.10	−4.25	−55.71	47.11
Wind x neighboring countries	−0.23	0.16	−1.40	−28.85	7.91
Wind x distant countries	0.66	0.13	5.06	84.56	68.90
Gas x Switzerland	0.16	0.18	0.90	21.06	6.98
Gas x neighboring countries	0.36	0.11	3.31	45.56	−34.58
Gas x distant countries	−0.52	0.14	−3.78	−66.63	−199.18
Location x Operator					
Switzerland x Swiss	−0.19	0.15	−1.30	−24.16	83.28
Switzerland x Non-Swiss	0.19	0.15	1.30	24.16	39.75
Neighboring countries x Swiss	0.43	0.10	4.31	55.36	96.73
Neighboring countries x Non-Swiss	−0.43	0.10	−4.31	−55.36	−105.84
Distant countries x Swiss	−0.24	0.14	−1.75	−31.20	−42.23
Distant countries x Non-Swiss	0.24	0.14	1.75	31.20	−71.69
Opt-out Option	−3.12	0.11	−27.16		
Choice observations	4932				
Individuals	411				
RLH	0.54				
Log likelihood	−3054.61				
Log Likelihood Null model	−5418.36				
χ^2 (*p*-value)	4727.49	0.000			
AIC	6139.22				
BIC	6236.78				

Table 16
MNL without interactions for latent class group Pro Landscape.

	Effect	Std Error	t-ration	Utilities (zero-centered differences)
Electricity source				
Solar	−0.15	0.21	−0.72	–
Wind	0.31	0.14	2.29	–
Natural gas	−0.16	0.19	−0.88	–
Location of electricity production				
Switzerland	−0.64	0.17	−3.71	–
Neighboring countries	0.49	0.13	3.78	–
Distant countries	0.15	0.15	1.05	–
Operator of the plant				
Swiss	0.54	0.12	4.57	–
Non-Swiss	−0.54	0.12	−4.57	–
Landscape impact				
Small impact	1.77	0.13	13.38	–
Strong impact	−1.77	0.13	−13.38	–
Increase in monthly electricity bill				
+10 CHF	0.88	0.15	5.91	–
+15 CHF	0.54	0.13	4.26	–
+20 CHF	−1.42	0.17	−8.32	–
Source x location				
Solar x Switzerland	–	–	–	−46.53
Solar x neighboring countries	–	–	–	20.08
Solar x distant countries	–	–	–	0.16
Wind x Switzerland	–	–	–	−19.43
Wind x neighboring countries	–	–	–	47.19
Wind x distant countries	–	–	–	27.26
Gas x Switzerland	–	–	–	−47.35
Gas x neighboring countries				19.27

(*continued on next page*)

Table 16 (*continued*)

	Effect	Std Error	t-ration	Utilities (zero-centered differences)
Gas x distant countries	–	–	–	−0.66
Location x Operator				
Switzerland x Swiss				−6.21
Switzerland x Non-Swiss	–	–	–	−69.33
Neighboring countries x Swiss	–	–	–	60.41
Neighboring countries x Non-Swiss				−2.71
Distant countries x Swiss	–	–	–	40.48
Distant countries x Non-Swiss	–	–	–	−22.64
Opt-out Option	−0.99	0.14	−6.87	
Choice observations	780			
Individuals	65			
RLH	0.62			
Log likelihood	−371.31			
Log Likelihood Null model	−856.92			
χ^2 (*p*-value)	971.22	(0.000)		
AIC	760.66			
BIC	802.55			

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.enpol.2019.03.054.

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