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Consumer preferences and the energy transition

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Background

- After the Fukushima accident (2011), Switzerland decided to phase out nuclear generation
- Swiss Energy Strategy 2050 (2013): low-carbon generation should replace nuclear – currently accounting for ∼40% of national demand
  - Sun and wind should play the main role
  - Electricity grids strategy to ensure security and efficiency
- Three referenda have been called since 2013 on topics related to the national Energy Strategy:
  - “Green economy” – September 2016, rejected by 64% of voters
  - “Nuclear withdrawal” - November 2016, rejected by 54% of voters
  - “Energy Strategy 2050 first implementation package” - May 2017, approved by 54% of voters

Aim & Method

National and local referenda can hinder the implementation of new energy policies in Switzerland

→ Assessing the preferences of Swiss household consumers toward:

1. Different primary energy sources used for generating electricity
   - Socio-economic drivers
   - Behavioural drivers
   - Psychological drivers: literacy, awareness, risk attitudes, …
2. The risk of experiencing a blackout / the possibility of providing demand response

Method: a discrete choice experiment

What drives the choice of green electricity?

Several analyses have investigated consumers' preferences toward attributes of electricity supplies and "green" features of energy-related goods and services. The results suggest:

- A positive willingness-to-pay (WTP) for green energy supplies
- Conflicting evidence as regards the impact of demographic variables: age, gender, education level, income, rural vs urban location, …
- Suggest a stronger impact of behavioural and attitudinal variables

(Green attributes of electricity supplies in OECD countries: *Goett & Hudson & Train 2000, Wuestenhagen & Markard & Truffer 2003, Burkhalter & Kaenzig & Wuestenhagen 2009, Zoric & Hrovatin 2012, Kaenzig & Heinzle & Wuestenhagen 2013, Tabi & Hille & Wuestenhagen 2014, Bauwens 2016, Salm & Hille & Wuestenhagen 2016, Yang & Solgaard & Haiderb 2016,…*)

Behavioural and attitudinal drivers

- Environmental awareness and concerns - Perceived effectiveness of coping behaviour
  (Ward et al., 2011, Zoric & Hrovatin 2012, Bauwens 2016, Tabi & Hille & Wuestenhagen 2014,...)

- Generosity, fairness, altruism, “warm glow”
  (Fischbacher et al. 2015, Blasch & Ohndorf 2016, …)

- Identification with groups of peers, preference for local producers or investment
  (Goett & Hudson & Train 2000, Salm & Hille & Wuestenhagen 2016…)

- Energy and investment literacy
  (Blasch, Boogen, Filippini & Kumar 2017, …)

Discrete Choice Analysis

Discrete Choice (DC) Analysis: operational theory of human behaviour:

- Assumes that the decision maker, when faced with a set of mutually exclusive and collectively exhaustive alternatives (goods/services), selects the one providing the highest utility
- Is based on the Random Utility Theory: the agent's utility is made up of an observable, systematic component and an unobservable, probabilistic component
- If applied to stated preferences, allows the evaluation of characteristics of the good/services that are not yet observable – e.g. new attributes or new levels for the existing attributes

Choice tasks – An example

Choose, out of 5 electricity supply contracts, the one you would sign for your own place:

Please choose the electricity supply contract that you like most for your dwelling:					
	nuclear	mix - of which 60% from renewables	hydro	sun	wind
price (rp/kWh)	18	27.5	21	24	50
nr of 5 minutes blackouts per year	0	1	1	4	1
nr of 4 hours blackouts per year	4	4	0	0	0
Your choice:					

Attribute levels

Attribute levels reflect average 2014 values (in red) and extremes we could expect in the future

		alternatives				
		nuclear	mix	hydro	sun	wind
attributes	price (rp/kWh)	14.5, 18, 21, 24, 27.5, 50	14.5, 18, 21, 24, 27.5, 50	18, 21, 24, 27.5, 50	21, 24, 27.5, 50	18, 21, 24, 27.5, 50
	nr of 5 minutes blackouts per year	0, 0.25, 1, 4				
	nr of 4 hours blackouts per year	0, 0.25, 1, 4				
	% of electricity from renewable energy sources		40, 60, 80, 100			

Data collection: survey

Web-based survey:

- February 2015
- Stratified sample of 1’006 Swiss residents
- Response rate: 37%

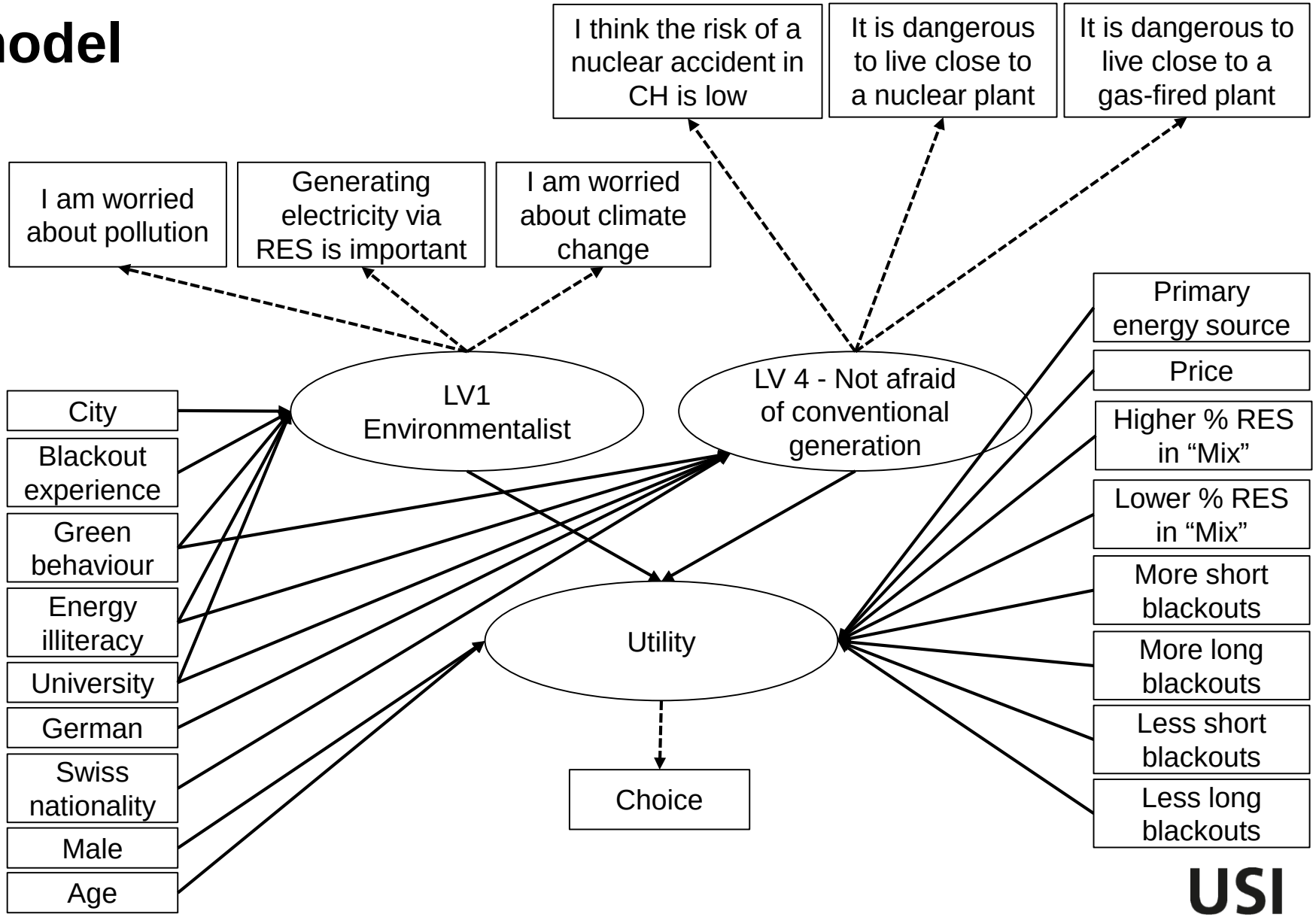
The survey covered:

- 8 choice tasks, obtained by means of efficient design with blocking
- Demographic variables
- Energy-related behaviour
  - Behaviour, equipment, literacy
- Agreement / disagreement with a set of statements related to energy and environmental issues
  - Climate change, pollution, nuclear, coal, gas, wind, RES in general, risk of blackouts, increasing prices

PCA on attitudinal indicators

		LV1 "Environmentalist"	LV2 "Conservative attitude"	LV3 "Pro import attitude"	LV4 "Not afraid of conventional 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

The discrete choice model



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DC model with latent variables (LV):

DC model

- Structural eq. $V_{i,k} = X_i^* \beta_1 + X_i \beta_2 + Z_k \beta_3 + \varepsilon_{i,k}, \qquad \varepsilon \sim EV(0, \Sigma_\varepsilon)$
- Measurement eq. $y_{i,k} = 1 \text{ if } V_{i,k} = \max_{\forall j \in C_n} \{V_{i,j}\},\ y_{i,k} = 0 \text{ otherwise}$

LV model

- Structural eq. $X_i^* = X_i \gamma + \mu_i, \qquad \mu \sim N(0, \Sigma_\mu)$
- Measurement eq. $I_i = X_i^* \alpha_1 + X_i \alpha_2 + v_i, \qquad v \sim N(0, \Sigma_v)$

Likelihood function:

$$f(y, I|X, Z; \alpha, \beta, \gamma) = \int_{X^*} P(y|X, X^*, Z; \beta) f(I|X, X^*; \alpha) f(X^*|X; \gamma) dX^*$$

DC model: Results (1)

Estimated parameters	MNL			Hybrid model with 2 LVs		
	Value	Robust std err		Value	Robust std err	
ASC_Hydro	-0.083	0.161		0.010	0.321	
ASC_Nuclear	-1.06	0.261	***	-0.418	0.559	
ASC_Sun	-0.358	0.167	**	-0.264	0.322	
ASC_Wind	0.257	0.168		0.350	0.320	
B_price_Hydro	-0.058	0.004	***	-0.058	0.004	***
B_price_Mix	-0.062	0.004	***	-0.062	0.004	***
B_price_Nuclear	-0.089	0.012	***	-0.092	0.012	***
B_price_Sun	-0.045	0.004	***	-0.045	0.004	***
B_price_Wind	-0.08	0.005	***	-0.080	0.005	***

- In the MNL model respondents show ceteris paribus preference toward Sun and dislike toward Sun. This disappears when we add LVs
- Price coefficients are significant and coherent in both models. They create an ordering of alternatives: Sun and Hydro rank first, Wind and Nuclear last

DC model: Results (2)

Estimated parameters	MNL			Hybrid model with 2 LVs		
	Value	Robust std err		Value	Robust std err	
B_lower_share_RES_Mix	0.159	0.215		0.166	0.216	
B_higher_share_RES_Mix	0.505	0.091	***	-0.241	0.261	
B_lower_f_short_blackouts	-0.036	0.034		-0.041	0.034	
B_higher_f_short_blackouts	-0.034	0.003	***	-0.034	0.003	***
B_lower_f_long_blackouts	-0.015	0.037		-0.014	0.037	
B_higher_f_long_blackouts	-0.106	0.004	***	-0.107	0.004	***

- In the MNL respondents place a positive value on having a higher share of RES in the Mix alternative; this disappears when we include LVs
- The coefficients for a decreased frequency of short and long blackouts are not significant in both models
- But the coefficients for a higher frequency of short and long blackouts are negative, significant and of comparable relative magnitude in both MNL and hybrid model

DC model: Results (3)

Estimated parameters	MNL		Hybrid model with 2 LVs		
	Value	Robust std err	Value	Robust std err	
B_age_Nuclear			-0.015	0.007	**
B_age_RES			-0.015	0.004	***
B_male_Nuclear			0.733	0.187	***
B_male_RES			0.002	0.097	
LV1_Mix			-0.302	0.266	
LV1_RES			-0.201	0.274	
LV1_%RES_MIX			0.146	0.048	***
LV4_Nuclear			0.564	0.347	*

- Older respondents are less interested in the primary energy sources used
- Men are more likely than women to choose Nuclear

- «Environmentalists» (LV1) do not care about the primary energy source used, but they place a strongly positive value on having a larger share of RES in the Mix alternative
- Those who are «Not afraid of conventional generation» (LV4) place a positive value on the Nuclear alternative

DC model: Results (recap)

Estimated parameters	MNL			Hybrid model with 2 LVs		
	Value	Robust std err		Value	Robust std err	
ASC_Hydro	-0.083	0.161		0.010	0.321	
ASC_Nuclear	-1.06	0.261	***	-0.418	0.559	
ASC_Sun	-0.358	0.167	**	-0.264	0.322	
ASC_Wind	0.257	0.168		0.350	0.320	
B_price_Hydro	-0.058	0.004	***	-0.058	0.004	***
B_price_Mix	-0.062	0.004	***	-0.062	0.004	***
B_price_Nuclear	-0.089	0.012	***	-0.092	0.012	***
B_price_Sun	-0.045	0.004	***	-0.045	0.004	***
B_price_Wind	-0.08	0.005	***	-0.080	0.005	***
B_lower_share_RES_Mix	0.159	0.215		0.166	0.216	
B_higher_share_RES_Mix	0.505	0.091	***	-0.241	0.261	
B_lower_f_short_blackouts	-0.036	0.034		-0.041	0.034	
B_higher_f_short_blackouts	-0.034	0.003	***	-0.034	0.003	***
B_lower_f_long_blackouts	-0.015	0.037		-0.014	0.037	
B_higher_f_long_blackouts	-0.106	0.004	***	-0.107	0.004	***
B_age_Nuclear				-0.015	0.007	**
B_age_RES				-0.015	0.004	***
B_male_Nuclear				0.733	0.187	***
B_male_RES				0.002	0.097	
LV1_Mix				-0.302	0.266	
LV1_RES				-0.201	0.274	
LV1_%RES_MIX				0.146	0.048	***
LV4_Nuclear				0.564	0.347	*

LV1 model: Results

LV1 Enviromentalist	Value	Robust Std err	
LV1_city	0.647	0.185	***
LV1_green_behaviour	1.750	0.055	***
LV1_had_blackout	0.600	0.141	***
LV1_illiteracy	0.515	0.058	***
LV1_university	0.995	0.129	***
I am worried about climate change (att_29)	fixed		
I am worried about pollution (att_12)	0.165	0.027	***
Generating electricity via RES is important (att_28)	0.088	0.024	***
Inter1_att12	4.990	0.152	***
Inter1_att28	5.920	0.131	***
Sigma1_star_att12	1.280	0.037	***
Sigma1_star_att28	1.030	0.042	***
Sigma1_star_att29	1.990	0.044	***

Positive correlation with the probability of having a higher score in LV1 «Environmentalist»:

- Shows a green behaviour – perceived effectiveness of coping behaviour?
- Has a university title
- Lives in a city
- Has experienced a blackout
- Has a higher score in the energy illiteracy index – Warm glow effect? Importance of clear labels?

LV4 model: Results

LV4 Not afraid of conventional generation	Value	Robust Std err	
LV4_swiss	-0.002	0.000	***
LV4_german_lang	-0.361	0.220	*
LV4_green_behaviour	-1.350	0.088	***
LV4_illiteracy	-0.482	0.064	***
LV4_university	-0.182	0.129	
It is dangerous to live close to a gas-fired generation plant (att_17)	fixed		
I think the risk of a nuclear accident in Switzerland is very low (att_9)	0.167	0.051	***
It is dangerous to live close to a nuclear generation plant (att_25)	-0.142	0.061	**
Inter4_att9	4.810	0.190	***
Inter4_att25	4.100	0.224	***
Sigma4_star_att9	1.830	0.028	***
Sigma4_star_att17	1.960	0.045	***
Sigma4_star_att25	1.910	0.029	***

Negative correlation with the probability of having a higher score in LV4 «Not afraid of conventional generation»:

- Does not show a green behaviour
- Is energy literate
- Speaks German
- Has Swiss citizenship
- Has a university title (weak)

Goodness of fit

Estimation report	MNL	Hybrid model with 2 LVs
Number of draws	-	1'000
Number of estimated parameters	15	47
Sample size	1'006	1'006
Initial log likelihood	-11'334	-31'300
Final log likelihood	-8'908	-20'282
McFadden adj. R squared	0.21	0.35

A significant improvement in goodness of fit is obtained by taking into account taste heterogeneity and its drivers

Conclusions (1)

There is significant heterogeneity in consumers' preferences toward alternative energy sources

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)
- A varying sensitivity to price increases, with generally lower values for RES than for "grey" and nuclear energy, with the exception of wind

Gender and age also play a role:

- Men are less likely than women to oppose nuclear generation
- Older respondents are less sensitive to the kind of energy source used

Conclusions (2)

LV1

Pro-environmental attitude:

- A stronger LV1 does not imply a specific preference for a single renewable energy source, but rather for a greener supply irrespective of the RES used
- The policy maker (or electricity suppliers) can exploit this for greening the economy (or their own supply portfolio) in the most sensible or cheapest way

LV4

Positive attitude toward nuclear and thermal generation:

- A higher energy literacy is generally associated to a higher LV4
- Providing accurate information may help minimizing or managing opposition to generation technologies that are usually perceived as undesirable for environmental or safety reasons

Thanks for your attention!

Demographic variables

Sample versus Swiss population at the end of 2014:

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%

Additional questions covered:

- City of residence
- Nr of people living in the household
- Nr of children (age<15) living in the household
- Size and ownership of the flat/house
- Education level
- Occupational status
- Income

Behavioural variables

Derived indexes:

- Green behaviour
  (0-3; switches lights off + switches heating off + has a renewable electricity contract)
- Energy illiteracy
  (0-8; sum of «I don't know» answers to equipment questions and amount of electricity bill question)
- Green equipment
  (0-7; sum of «yes» answers to equipment questions)

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%	

Attitudinal questions

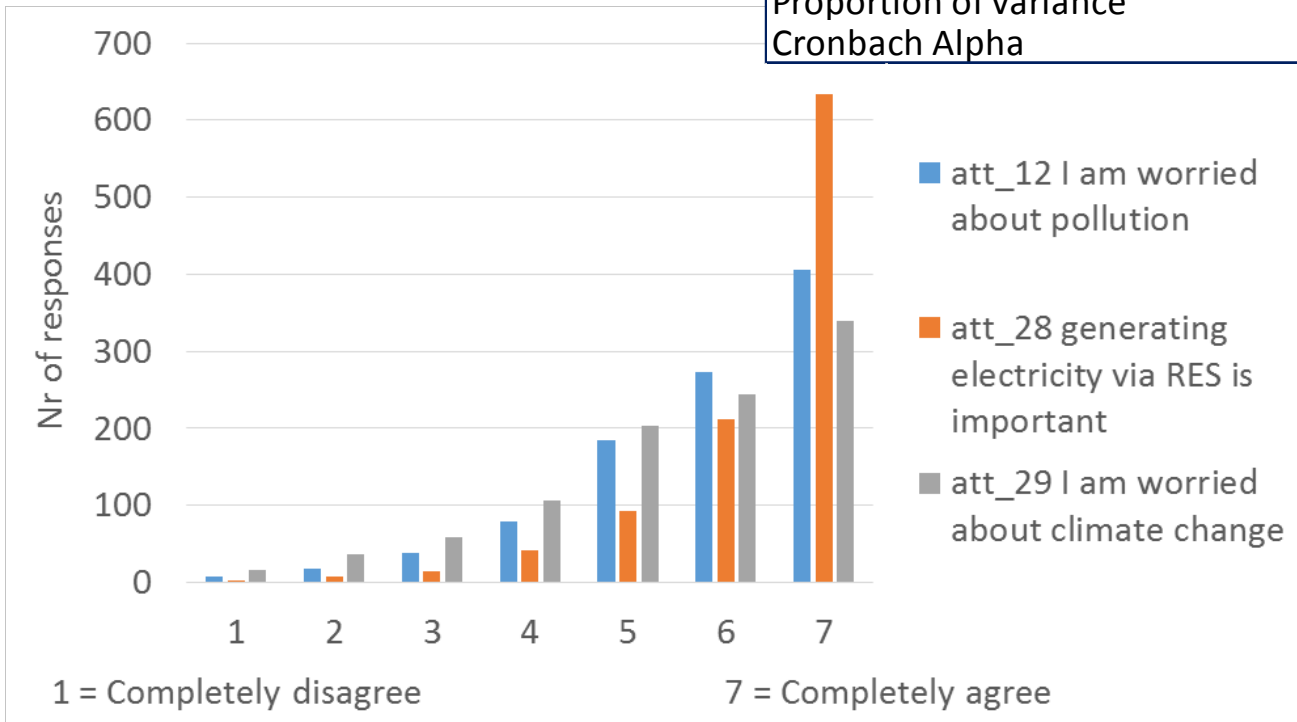
Each respondent expressed on a 7-point likert scale his/her agreement with a series of 30 statements regarding:

- Nuclear, coal- and gas-fired generation
- The use of renewables for generating electricity
- Wind generation as a threat to landscape and local populations
- Electricity imports
- Blackouts
- Increasing electricity prices
- Climate change
- Environmental pollution

LV 1 «Environmentalist»

- Good internal consistency
- Definite stance towards climate change, pollution and RES

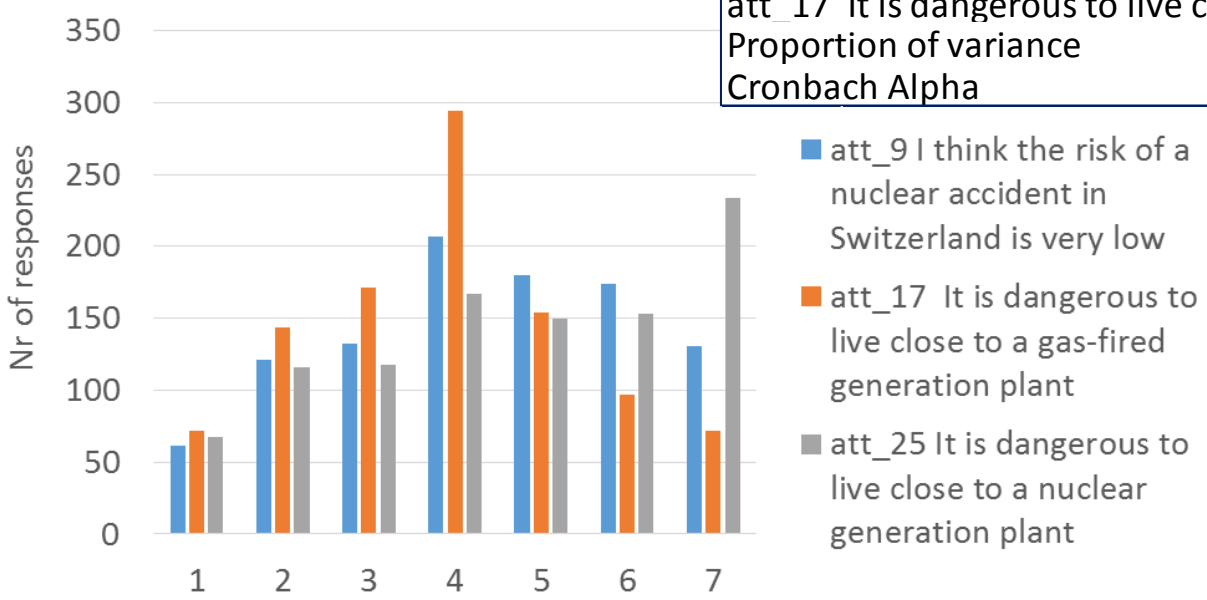
"Environmentalist"	
att_29 I am worried about climate change	0.30
att_12 I am worried about pollution	0.30
att_28 Generating electricity via RES is important	0.29
Proportion of variance	20.8%
Cronbach Alpha	0.76



LV 4 «Not afraid of conventional generation»

"Likes nuclear and gas-fired generation"		
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	-0.40
att_17	It is dangerous to live close to a gas-fired	-0.42
Proportion of variance		6.7%
Cronbach Alpha		0.69

More balanced distribution of responses



1 = Completely disagree 7 = Completely agree

- Good internal consistency
- Definite stance toward two generation technologies

Composition of the sample

Education	
Obligatorische Schule	0%
Haushaltslehrjahr, Handelsschule	2%
Anlehre	1%
Diplommittelschule, allgemeine Schule	3%
Berufslehre	29%
Vollzeitberufsschule	4%
Maturität, Lehrerseminar	9%
Universität, ETH, FH, PH, höhere Berufsausbildung	53%

Occupation	
Student	1%
University student	9%
Apprentice	1%
Housewife / houseman	3%
Employee	66%
Freelance	4%
Enterpreneur	5%
Farmer	0%
Retired	3%
Unemployed	4%
Other	2%

Composition of the sample

Net income per household	
Below 4'000 Fr.	18%
Between 4'001 and 7'000 Fr.	32%
Between 7'001 and 8'500 Fr.	11%
Between 8'501 and 10'500 Fr.	13%
Between 10'501 and 16'000 Fr.	11%
Above 16'000 Fr.	3%
I don't know / No answer	11%

Region of residence	
Westschweiz	25%
Alpen, Voralpen	22%
Westmittelland	25%
Ostmittelland	28%

Composition of the sample

Nationality and housing solutions			
Nationality		**Housing size category**	
Swiss	80%	1 person	47%
Italian	3%	2 people	25%
German	5%	3+ people	28%
Spanish	1%	Missing value	0%
Portuguese	0%	**Kind of housing solution**	
Croatian	0%		
Serbian	0%	Rented flat	67%
French	3%	Rented house	3%
Turkish	0%	Own flat	11%
Austrian	1%	Own house	21%
UK	1%	More than one	2%
USA	0%	**Lives in:**	
Dutch	1%	Stadt	51%
Other	3%	Agglo	28%
Multiple nat.	9%	Land	21%

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How much do you agree with the following statement on a scale from 1 (completely disagree) to 7 (completely agree)?		Mean	Std.Dev.
att_16	I'm NOT worried about the risk of a nuclear accident in CH	3.4	2.0
att_9	I think the risk of a nuclear accident in Switzerland is very low	4.2	1.8
att_25	It is dangerous to live close to a nuclear generation plant	4.6	1.9
att_2	Decommissioning Swiss nuclear plants is a good idea	5.1	2.0
att_4	CO2 emissions from coal, oil and gas cause global warming	5.8	1.3
att_26	Climate change would be bad for mankind and enviroment	6.0	1.3
att_29	I am worried about climate change	5.5	1.5
att_12	I am worried about pollution	5.8	1.3
att_24	I'm personally in charge of my environm.friendly behaviour	6.0	1.3
att_23	Our society should use less fossil fuels to reduce pollution	5.9	1.3
att_19	Everybody should behave in an environmental-friendly way	6.4	1.0
att_5	Saving energy in everyday life is important	6.2	1.1
att_30	I find blackouts annoying	4.9	1.7
att_20	I am frightened when there is a blackout at my place	2.4	1.5
att_18	Blackouts can be very costly for private companies	5.3	1.5
att_6	Blackouts can be costly for households	4.1	1.7
att_7	I am worried about increasing electricity prices	4.4	1.8
att_28	Generating electricity via RES is important	6.4	1.0
att_14	Most private buildings should have PV panels	5.6	1.5
att_10	New plants from RES needed for increasing el. demand	6.0	1.3
att_1	New generation plants important to cover increasing el. demand	4.7	1.7
att_11	it is dangerous to live close to a coal generation plant	4.3	1.7
att_17	it is dangerous to live close to a gas-fired generation plant	3.9	1.6
att_3	it is safe to import electricity from abroad	3.4	1.5
att_15	Import dependency for el. supplies endangers our economy	4.5	1.6
att_22	I'm worried about depending on foreign countries for energy	4.4	1.6
att_27	Electricity can be safely imported from abroad	3.2	1.6
att_21	Wind turbines spoil the landscape	2.9	1.7
att_8	Wind turbines are noisy and disturb local populations	3.1	1.6
att_13	Wind turbines kill birds and damage fauna	3.3	1.6

Definition of the choice experiment: hints from the literature

- Risk of strategic behaviour: choice of a green supply as a voluntary contribution to a public good / addition of a public good feature to a private good
- Limited trust in / limited understanding of green options: the choice framework should be easily understood by respondents
- Landlord / tenant problem