Issues related to the installation of solar panels and preferences for next-generation energy : A case study of Switzerland as it aims for withdrawal from nuclear energy.

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Abstract

This paper examines the public awareness of next generation energy sources and the issues surrounding the installation of solar panels, taking Switzerland as a case-study. After the 2011 Fukushima nuclear disaster, over half of Swiss citizens believed a shift in energy policy was required and three quarters believed renewable energy should be expanded. This research found a lot of support was rooted in addressing climate change, but that the greatest concern surrounding the installation of solar panels was the negative impact it would have on the natural environment. A comparison with a similar study in Russia found that Swiss participants were more likely to be swayed by the introduction of a feed-in tariff but were also more likely to be concerned about possible increased electricity prices. Age was found to have a negative correlation with increased renewable energy tariffs on energy bills, whereas education had a positive correlation.

1. Introduction

On May 21, 2017, the Swiss people gave their support to the government's long-term energy strategy to reduce dependence on nuclear power in a nation-wide referendum [1]. According to the Swiss Broadcasting Corporation, with a turnout of 42.3%, support for the proposed law was 58.2%, with 41.8% opposing. The new Energy Law established the Energy Strategy 2050, which included the phasing out of nuclear energy by 2050, starting with the banning of any new commissions. At the same time, the government would actively promote renewable energy and energy conservation [1].

There are a range of possible reasons for this broad support to abandon nuclear power. Not least among them are accidents involving nuclear power plants, such as incidents in Switzerland, Chernobyl, and most recently Fukushima. Southern parts of Switzerland are still suffering from the fallout of the

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Chernobyl accident. When, on March 11, 2011, the Fukushima Daiichi nuclear power plant suffered an accident on the same scale as Chernobyl, the Swiss federal government made the momentous decision on May 25 to abandon nuclear power as an energy source. Five of the currently operating nuclear power plants – Beznau, Gösgen, Leibstadt, and Mühleberg – have been classified as obsolete (as of 2020), and thus will be decommissioned. 2034 should mark the end of Switzerland's nuclear program with the final closure of Leibstadt [2] [3].

Taguchi [4] describes the history of Swiss denuclearization from the 1970s to the Fukushima Daiichi Nuclear Power Plant accident, in particular the Kaiseraugst anti-nuclear movement and the cancellation of power plants following the Chernobyl accident. Imai [5] concludes that the anti-nuclear movement in Switzerland was heavily influenced by similar earlier movements, and that Fukushima had a significant impact on Switzerland's energy strategy. JAEA [2] gives a schematic summary of the Swiss energy and nuclear policy. Takigawa [6] describes the impact of the 1985 Energy Act, including tax subsidies to promote renewable energy and energy conservation, and the subsequent 1999 Amendment that introduced additional further energy saving tax incentives. On the other hand, Katano [7] argues that the Geneva based SIG (Services Industriels de Genève) put forward a mixed energy program including hydro, nuclear, fossil and renewable energy sources as the way to move forward to a new energy policy.

Swiss winters have very few hours of daylight, and along with unreliable wind means renewable energy such as solar power and wind power is neither reliable nor attractive. However, as a consequence of rising opposition to nuclear power and leaks of radioactive material from nuclear power stations, Switzerland was the first country in Europe to install a solar power plant, in 1982[8]. After the Chernobyl nuclear plant accident, Switzerland became the leading producer of solar power by 1992[8]. Despite this, because of vested interests within the energy sector, there was reluctance to accept renewable energy, and solar power was not widely adopted.[1] Thus, compared to Austria, with a similarly mountainous topography, solar powered water heaters covered six times less area, and per capita wind power generation was 55 times less in Switzerland [9]. Compared to its neighbours Germany and Austria, Switzerland has been slow to adopt renewable energy. Since the introduction of feed-in tariffs in 2009, the popularity of solar power generation has grown amongst urban and rural households, as compared with wind power and biomass energy generation. Therefore, when placing solar panels, it is important to consider the environmental and visual impact it has. For Switzerland, consideration of the human and natural environments plays an essential and guiding role in the success of a sustainable, next-generation energy policy.

In this paper, we will examine how these considerations have helped shape Switzerland's solar power energy policy.

2. Methodology

2.1 Paper Structure

The structure of this paper is as follows :

Section 2 describes the structure of this paper, the design of the questionnaire, and the method of

analysis of the research.

Section 3 considers the reasons for Switzerland's decision to withdraw from nuclear power and the results of the referendum on the withdrawal of nuclear power.

In Section 4, we consider the following issues on the Swiss people's decision : (1) what impact the Fukushima accident had : (2) support for (or opposition to) the inclusion of renewable energy as part of their future energy policy ; (3) the reasons for opposing or supporting renewable energy ; (4) the challenges of solar panel installation ; and (5) what role taxation should play in renewable energy.

Section 5 examines the level of knowledge amongst Swiss people of incidents involving radiation and leaks from nuclear plants in France, and the level of faith in the information provided by the French government. Ordinal logistic regression is used to model this onto energy policy preferences. The tobit model is then used to estimate the relationship between personal policy preferences and the individual's willingness to pay for renewable energy.

Section 6 examines the challenges Switzerland faces in the installation of solar panels in particular and its future energy policy in general.

2.2 Survey design and statistical methodology

2.2.1 Sampling and data collection

This section describes the survey design. Renewable energy is being promoted differently in each region of Switzerland, partly depending on the local language. Pre- and post-Chernobyl (and other disaster) generations can also be expected to be treated differently. Furthermore, since the appearance of Swedish environmental activist Greta Thurnberg from February 2019, personifying and articulating the concerns of young people around the world, there has been a generational shift in knowledge and attitudes regarding environmental issues, and renewable energy in particular. Through statistical analysis of survey data, this paper will examine whether the null hypothesis that support for solar power is not affected by differences in individual attributes can be rejected, and that the alternative hypothesis that there is a difference in support depending on individual attributes can be confirmed.

The survey was made using SurveyMonkey and then distributed through a consumer polling service (chosen by SurveyMonkey). Although there are four linguistic groups in Switzerland (French, German, Italian and Romansh), English is also an official language, so the survey was conducted in English to simplify the whole process and prevent any translation errors or confusion.

The survey area covers the whole of Switzerland, with 339 respondents, 301 of which responded completely (completion rate of 88.8%). The survey was carried out between Friday, September 20 to Saturday, September 21, 2019. Samples were selected so as to represent the population as accurately as possible by gender and age, following the method used by the polling service. However, as is often the case with online surveys, responses tended to favor the more heavily populated cantons, which unavoidably may result in a degree of bias in the overall results.

2.2.2 Statistical methods

First, the results of the survey are compared to similar surveys carried out in other European countries. The questions covered the respondents' knowledge of accidents involving nuclear power

plants, and their attitudes towards government responses and public announcements about the accidents. The comparison surveys are from Germany [10], France [11], Finland [12], the Ukraine [13], Belarus [14] and Russia [15]. As the question items are very similar, comparison is quite straightforward.

Secondly, French and Swiss respondents' awareness of incidents involving radiation leaks in France, and the credibility of the French authorities' responses and announcements are compared.

Third, we compare the results with the German [10] and French [11] surveys to see if the Swiss energy policy preferences have changed due to the Fukushima nuclear accident. Changes in German nuclear power policy preferences have been reported by Schreurs [16] and Klein [17]. In contrast, France has continued its support for nuclear power after the Fukushima accident [18]. Nakamura et al confirmed that the German public are aware that their energy policy has changed, while the French public are equally aware that theirs has not [10] [11]. We make a statistical comparison between these French and German results and the Swiss people's awareness of changes in energy policy due to the Fukushima nuclear accident.

Fourth, we compare and contrast Russian [19] and Swiss reasons for supporting or opposing renewable energy. Again, the survey items are directly comparable, making this very straightforward.

3. May 2017 referendum on withdrawal from nuclear power generation and the underlying reasons for withdrawal from nuclear power

This section examines the reasons why Switzerland abandoned nuclear power generation, the process of Switzerland's abandonment, and the background to the 2017 Energy Law.

3.1 Reasons behind Switzerland's abandonment of nuclear power

In this section, we will examine in detail the factors behind Switzerland's withdrawal from nuclear power. In Switzerland, five nuclear power plants supplied 40% of the country's electricity production and 9% of its total energy [6]. As the demand for electricity in Switzerland has been growing since 1990, the major power companies and various business organizations have been actively promoting the construction of new nuclear power plants, citing future power supply shortages and climate change as reasons. This is reflected in the Swiss Federal Assembly with several pro-nuclear groupings. The Federal Assembly, however, decided to phase out nuclear power on May 25, 2011, in the wake of the Fukushima accident.

The first factor to consider is that Switzerland has some of the oldest nuclear power plants in the world. As domestic demand for energy grew in the latter half of the 20th century, resource poor Switzerland looked to nuclear power as an option [4]. A total of seven nuclear power plants were commissioned, starting with construction in Beznau in the northern Canton of Aargau in 1964, and finishing with the newest plant, Leibstadt (also in Aargau), which, although construction started in December 1974, came online on May 24, 1984. This means the newest plant has been in operation for 36 years. Bezanu started operation on December 9, 1969, making it one of the oldest commercial nuclear power plants in the world [20].

A second factor is that Switzerland has had its own nuclear accident. On January 21, 1969, the gas-cooled underground reactor in Lucens, Vaud, experienced a loss of coolant that caused a core meltdown and leakage of radioactive material into the cave [22]. This has been classed as a Level 5 (accident with wider consequences) on the International Nuclear and Radiological Event Scale (INES) [8]. This would have an impact on Switzerland's objective of energy self-sufficiency through nuclear power [8].

The third contributing factor is the existence from the 1960s of an anti-nuclear power movement. Although the Beznau plant was greeted with widespread support, the accident at the Lucens reactor in 1969 led to a change in attitude of many people, and local pockets of opposition coalesced into a national movement. A central example of this is the Kaiseraugst opposition movement that opposed construction of a plant in the small village of that name. Located in the area where the Rivers Arr and Rhine meet, it is only 10km from Basel [4] [3]. Construction started in the late 1960s, but the protests came to a head in 1975 when 15,000 people came together to occupy the construction site for eleven weeks. Mass anti-nuclear protests sprung up around the country. The government was forced to back down and accept many of the democratically-formulated demands of the Kaiseraugst protesters. The Canton of Basel-Stadt took the opportunity to ban nuclear power, along with the ambitious commitment to fulfil all its energy needs from renewable energy sources [3].

Switzerland's experience with the April 26, 1986 Chernobyl nuclear accident is a fourth factor. The opposition movement had been growing, intensified by the 1979 Three Mile Island accident [21]. However, the Chernobyl accident quite literally brought the dangers of nuclear power into the lives of the Swiss people, blown in on the winds [3]. The southernmost Canton of Ticino experienced higher levels of cesium-137 than northern and northwestern areas of Switzerland.[2] Atmospheric radiation was up to 10 times that normally recorded in Switzerland [5]. The Swiss political system strongly favours direct democracy ; in order to initiate, amend or abolish a law, an initiative requires 100,000 signatures to include it on a legally binding referendum. An initiative on nuclear power, along with a chemical plant fire that polluted wide stretches of the Rhine in November of the 1986 led to the federal government deciding by the spring of 1988 to abandon the construction of the Kaiseraugst nuclear power plant [4].

A fifth factor is the frequent nuclear accidents in neighboring France. The Fessenheim power plant is the oldest one in France, having started operating in 1978. It is alongside the Grand Canal d'Alsace, is on the border with Germany, and only 40km north of Switzerland. It has experienced a number of INES level 1 incidents, including 2004, 2005, 2009, 2011 and 2014. The heat wave that hit Europe in 2019 led to the water from the Rhine being too hot to use in French and German nuclear reactors, resulting in their temporary shutdown.[3] Thus, Switzerland is faced not only with problems arising from its own aging nuclear infrastructure, but those of its neighbors too.

The sixth factor we suggest is the TEPCO Fukushima Daiichi nuclear power plant accident of March 2011. On March 14, just three days after the accident, Minister for Environment and Energy Doris Leuthard announced the suspension of all renovation and construction plans for nuclear plants. This led to widespread consternation around Europe and in France and Germany in particular [3]. On May 25, the Swiss federal cabinet took the decision to phase out all nuclear power plants [3]. Leuthard announced the schedule for decommissioning all of Switzerland's nuclear power plants : Beznau No 1 reactor in

2019, Beznau No 2 and Mühleberg in 2022, Gösgen in 2029 and finally Leibstadt in 2034 [3]. However, an accident at the Mühleberg plant resulting in a radiation leak on March 8, 2018, led to a temporary emergency shutdown, followed by a series of further minor accidents and shutdowns.[4] Given the technical problems and the general political trend, the operator BKW (Bernische Kraftwerke AG), bowed to the inevitable and closed the plant on December 20, 2019 [8].

As the above illustrates, there are a wide variety of reasons for Switzerland's abandonment of nuclear energy. Now that this withdrawal is underway, the next step is to plan for the future generation of energy sources.

3.2 Swiss referendum on nuclear withdrawal

The next section will look at the twists and turns that preceded the referendum to end Switzerland's dependency on nuclear power.

A February 1979 initiative proposed by the anti-nuclear power movement giving greater local and democratic control on the locating of nuclear power plants was narrowly rejected in a referendum [5]. However, in May of the same year, the federal government proposed amending the Atomic Energy Law to tighten the licensing of construction of nuclear power plants, which was subsequently adopted in a referendum [5]. Two further initiatives in 1984 (one proposing an outright ban, the other prioritizing safety and environmental protection) were rejected by the electorate [5].

The referendum of September 23, 1990 proposed a series of initiatives. The first, prohibiting the construction of any new nuclear power plants and the decommissioning of the existing ones as soon as possible, was rejected by 52.9% of voters. However, a second initiative, proposing a 10 year moratorium on construction of plants was approved by 54.5% [5].

Anti-nuclear power proponents brought forward proposals in 2003 to extend the moratorium for another 10 years, and gradually close all the five operating power plants by 2014.[5] However, the first proposal was rejected by 58.4% and the second by 66.3% in the referendum [5]. Takai [21] states this was indicative of a surge in support for nuclear power in Switzerland, further illustrated by an amendment to the Nuclear Energy Act ending the moratorium in 2005 ; approval in 2008 of applications for refurbishing in Beznau, Gösgen, and Mühleberg ; and a further local referendum in Bern in 2010, in which 51% of voters supported rebuilding the Mühleberg plant.

However, all this came to an abrupt change after the Fukushima accident, and support for denuclearization accelerated immediately. The Energy Strategy 2050 announced in the aftermath of Fukushima, ended construction of new nuclear power plants and the phasing out of the five current plants. However, no operational limit was set for the relatively new Leibstadt power plant once its safety was confirmed. The Strategy allowed for nuclear power to continue supplying about 39% of the country's electricity, due to the perceived economic burden of renewable energy. The right-wing populist Swiss People's Party (SVP) won a concession in the Assembly that no limit would be set on how long the remaining plants operated [8]. This Strategy was opposed by a large portion of the Swiss population, with an initiative gaining 50,000 signatures in 100 days, and led to a May 21 2017 referendum. With 58.2% supporting the renewable energy proposals, the Revised Energy Act was made a statutory reality.

(as mentioned in Section 1).

4. Survey Outline

This section looks at the sample results on how public attitudes to Switzerland's energy policy have changed, support (or opposition) for next-generation renewable energy, and preferences for how renewable energy will be financed through taxation.

4.1 Sample details

Table 1 shows survey sample attributes. First, looking at gender, males accounted for 29.2% and females accounted for 70.8%. 68.1% of households had no children (or grandchildren) under 12 years of age.

Zürich, the largest metropolitan area in Switzerland, accounted for 19.9% and Bern, where the capital is located, accounted for 11.6%. In addition, 10% of respondents are from Vaud, where the judicial capital Lausanne is located ; Aargau, the centre of optical equipment and precision machinery production along the Aar River, accounted for 7.9% ; and 7.3% of respondents were from Genève, centre for many multinational organizations.

Most of the respondents reported their occupation as general office workers (27.9%), self-employed (12.3%), public employees (10.6%), and engineering/specialists (10.0%). The average age is 39.9, and the largest age groups are 30-39 (28.2%), 40-49 (24.6%), 20-29 (23.3%), and 50-59 (13.6%).[5] The educational background is mostly junior college/technical college (33.6%), 25.9% with university degrees and 16.9% with graduate education.[6]

The average monthly income is reported as CHF 6,062.3 (Swiss franc), which is USD 6,164.3 (CHF 1 = USD 1.0168). The average annual income of the respondent is estimated to be USD 73,971.5. The GDP per person in Switzerland in 2018 was USD 83,162 (IMF), so the sample in this paper has a slightly lower income level. The largest income group is CHF 5,001-6,001 with 17.6% of respondents, CHF 4,001-5,000 with 15.9% and CHF 6,001-7,000 with 15.9%.

4.2 Knowledge of nuclear accidents, trust in government statements and responses, and the impact these have on attitudes towards renewable energy

Table 2 shows the responses given regarding the survey participants' recollection of past accidents, their attitude towards government statements and actions, and their support levels for renewable energy.

4.2.1 Knowledge of nuclear power plant accidents

First, it was revealed to the survey participants that the reported values of cesium-137 in soil samples increased in northern and northwestern Switzerland at the time of the Chernobyl nuclear accident (see Section 3). The participants were asked, "How aware are you of the Chernobyl nuclear accident?" The number of those who are "somewhat aware" (38.2%) were in the majority, and those who are "very aware" (23.9%), totalling 62.1% with some degree of knowledge of the Chernobyl accident.

Compared to six other countries surveyed, Switzerland showed the lowest level of

Table 1　Survey details (n=301)

Attribute		count	% of n	Attribute		count	% of n
Age	under 19	8	2.7%	Sex	Male	88	29.2%
	20～29	70	23.3%		Female	213	70.8%
	30～39	85	28.2%	Children	under 12	96	31.9%
	40～49	74	24.6%		no children under 12	205	68.1%
	50～59	41	13.6%		Average family size / SD	2.55	1.2
	60～69	16	5.3%	Occupation	General office work	84	27.9%
	Over 70	7	2.3%		Public employee	32	10.6%
	Average / SD	39.9	13.2		Construction	20	6.6%
Education	junior high	12	4.0%		Engineering/Specialist	3	1.0%
	senior high	49	16.3%		Self-employed	37	12.3%
	college/trade	101	33.6%		Agriculture/fisheries	4	1.3%
	university	78	25.9%		Homemaker	22	7.3%
	graduate	51	16.9%		Retired	14	4.7%
	post graduate	10	3.3%		Unemployed	12	4.0%
Canton	Zürich	60	19.9%		Student	24	8.0%
	Bern	35	11.6%		Incapacitated/Furlough	5	1.7%
	Vaud	30	10.0%		Sales/management	8	2.7%
	Aargau	24	8.0%		Other	9	3.0%
	Genève	22	7.3%	Monthly salary	less than CHF 1,000	26	8.6%
	Luzern	14	4.7%		CHF 1,001～2,000	16	5.3%
	Solothurn	13	4.3%		CHF 2,001～3,000	22	7.3%
	Sankt Gallen	13	4.3%		CHF 3,001～4,000	27	9.0%
	Freiburg	12	4.0%		CHF 4,001～5,000	48	15.9%
	Basel-Landschaft	10	3.3%		CHF 5,001～6,000	53	17.6%
	Zug	9	3.0%		CHF 6,001～7,000	37	12.3%
	Basel-Stadt	9	3.0%		CHF 7,001～8,000	23	7.6%
	Schwyz	8	2.7%		CHF 8,001～9,000	11	3.7%
	Ticino	7	2.3%		CHF 9,001～10,000	10	3.3%
	Wallis	7	2.3%		CHF 10,001～12,000	9	3.0%
	Neuchâte	6	2.0%		CHF 12,001～14,000	1	0.3%
	Thurgau	5	1.7%		CHF 14,001～16,000	5	1.7%
	Glarus	3	1.0%		CHF 16,001～18,000	1	0.3%
	Jura	3	1.0%		CHF 18,001～20,000	1	0.3%
	Nidwalden	3	1.0%		CHF 20,001～22,500	2	0.7%
	Uri	3	1.0%		CHF 22,501～25,000	2	0.7%
	Appenzell Ausserrhoden	2	0.7%		CHF 25,001～27,500	0	0.0%
	Shaffhausen	1	0.3%		CHF 27,501～30,000	1	0.3%
	Appensell Innerhoden	1	0.3%		over CHF 30,001	6	2.0%
	Graubünden	1	0.3%		Average / SD	6,062.3	5,258.9

Source : SurveyMonkey
Note : 1) Children means children under 12 years old.
Note : 2) Mean and SD (standard deviation) of age and income were calculated using class values.
Note : 3) Others include 1 nurse, 1 teacher, 1 craftsman.

Table 2 Knowledge of nuclear accidents, faith in government statements and actions, change in energy preferences and support for renewable energy (n=301)

Item	Response / Question	Very aware	Somewhat aware	neither	not so aware	unaware	Average SD
Chernobyl nuclear accident	How aware are you of the 1986 Chernobyl accident?	23.9%	38.2%	26.2%	7.0%	4.7%	3.698
		72	115	79	21	14	1.054
French radioactive leak	How aware are you of radioactive leaks in French nuclear power plants?	20.3%	28.6%	25.2%	12.0%	14.0%	3.292
		61	86	76	36	42	1.302
Item	Response / Question	high level of trust	somewhat trusting	neither	low level of trust	no trust	Average SD
Trust in statements of the former Soviet authorities	How much trust did you place in the statements of the Soviet authorities regarding the nuclear accident?	9.3%	20.6%	28.9%	18.6%	22.6%	2.754
		28	62	87	56	68	1.27
Trust in statements of the French authorities	How much trust did you place in the statements of the French authorities regarding the leaks?	8.6%	24.9%	27.2%	24.9%	14.3%	2.887
		26	75	82	75	43	1.186
Item	Response / Question	Large change	Somewhat changed	neither	minor change	no change at all	Average SD
Change in energy preferences	After the Fukushima accident, did your preferences for Swiss energy policy change?	23.3%	33.2%	29.2%	10.6%	3.7%	3.618
		70	100	88	32	11	1.066
Item	Response / Question	strong support	somewhat supporting	neither	minor support for fossil fuels	strong support for fossil fuels	Average SD
Support for renewable energy	Do you believe the government should expand renewable energy?	45.5%	31.2%	18.9%	2.3%	2.0%	4.159
		137	94	57	7	6	0.946

Note : The average in the table is the average of the question items scored using a five-point Likert scale (the same applies to Tables 6 and 7).

awareness : Germany (98.2%), Belarus (88.0%), Russia (82.5%), Ukraine (73.1%), and Finland (71.7%). This may reflect the fact that Switzerland is the farthest away of these countries.

Second, France's oldest nuclear power plant, Fessenheim, is located on the border with Switzerland, and has experienced several accidents and leaks (see Section 3). The participants were asked "Are you aware of the leaks in French nuclear power plants?" The largest response was "somewhat aware" (28.6%). 20.3% responded "very aware", meaning a total of 48.8% indicating some level of awareness.

The results of a French survey indicate that 54.3% of respondents were aware of the Cattenom nuclear power plant accident of 2013, and 45.2% were aware of the 2013 leak at the Tricastin nuclear power plant [11]. This suggests Swiss respondents have similar levels of awareness as their French

counterparts.

4.2.2 Trust in government information disclosure on the nuclear power accidents

When asked about their trust in the former Soviet government's public statements regarding the Chernobyl accident, the largest group was unable to provide a response either way (28.9%). However, 22.6% said they had no trust in the statements, and 18.6% said little trust, totaling 41.2% showing a degree of skepticism about the statements put out by the former Soviet authorities. Switzerland has a good relationship with Russia, seeing it as a valuable, resource-rich economic partner and a positive presence in the United Nations [8]. Equally, Russia values Switzerland as a neutral country, a non-EU and non-NATO European state [8]. However, given the continued high levels of 137C in Ticino and Grisons [8], it is not surprising that there is a lack of trust in the statements of the Soviet-era government.

Comparing results with other countries surveys, Swiss respondents showed a high level of trust in the Russian statements. In the five countries surveyed, the scores for "high level of trust" and "somewhat trusting" combined are Belarus (46.0%), Russia (41.1%), Ukraine (35.7%), Switzerland (29.9%), Germany (8.4%), and France (5.4%), placing Switzerland in between CIS and other Western European countries.

Respondents were also asked about the credibility of French government pronouncements on nuclear accidents. The Fessenheim nuclear power plant, located on the French-Swiss border, has had several radiation leakages. The largest group said they were unable to say either way (28.9%), but the proportion that said "somewhat trustworthy" and "somewhat untrustworthy" was the same (24.9%). Switzerland and France have a long history of cooperation, dating back to the 1516 Traité de Fribourg establishing perpetual peace between the countries (briefly interrupted by Napoleon), followed in 1521 by a military treaty. According to a 2015 survey by the Swiss Department of Foreign Affairs (FDFA), 194,000 Swiss live in France and 163,000 French citizens live in Switzerland, and a further 150,000 cross the border to work in Switzerland. Despite this close relationship, many respondents were ambivalent about the information coming from French government about accidents occurring in its nuclear facilities.

However, when comparing the levels of trust with the French survey, 33.5% of Swiss participants indicated some or a lot of trust in the French government's statements, compared to only 14.0% of French respondents [11].

4.2.3 Changes in attitude after the TEPCO Fukushima Daiichi nuclear accident

After the Fukushima nuclear accident, a referendum was held in Switzerland on the issue of renewable energy and energy conservation, with the objective of ending nuclear power by 2050 (see Section 3).

Table 3 Multiple comparison of changes in energy policy (Tukey Method)

item	Comparison country 1	Comparison country 2	benchmark 1	benchmark 2	difference	p-value
Change in Energy policy	Germany	Switzerland	4.223	3.618	0.605	0.000***
	Germany	France	4.223	1.704	2.519	0.000***
	Switzerland	France	3.618	1.704	1.914	0.000***

Notes : *** indicates that mean difference is statistically significant at the 1% level.

When asked if their attitude on energy policy had changed after Fukushima, 33.2% reported some change and 23.3% a big change, suggesting a majority of people (56.5%) saw the Fukushima accident as significant in their energy policy preferences. Table 3 compares survey results from three countries on attitude changes as a result of Fukushima. The extrapolated results suggest that Germany experienced a significant shift in attitudes (4.223), Switzerland somewhat less (3.618) and France the smallest shift (1.704). The Swiss showed a bigger shift in energy policy attitudes than the French.

4.2.4 Intention to support renewable energy

EIA data indicates that solar and wind power generation makes up only 8.52% of Switzerland's total output (2017), which is lower than that of the nuclear power giant France (8.57%) and far lower than Germany's (32.85%). Participants were asked, in light of the current situation, would they support a renewable energy policy. 76.7% responded "strong support" (45.3%) or "somewhat support" (31.2%).

Below is a breakdown of the participants reasons for their position on supporting renewable energy.

Table 4 shows the reasons given for supporting renewable energy, and a comparison with responses in a Russian survey [19]. Russia was chosen because of its low renewable energy generation ratio of only 0.37% (EIA, 2017), thus comparable to Switzerland, the lowest adopter of renewable energy in Europe.

The most common reason for supporting renewable energy was "because of reduced CO_2, it helps prevent climate change" (39.2% of participants). Next, its lack of a need for finite fuel was chosen by 28.6% of people. Low or zero emissions, and the feed-in tariff system were both chosen by 23.3% of respondents.

Table 4 Reasons for supporting renewable energy (multiple responses possible) and cross-country comparison

item	count	% of total	Country Comparison CH-RU
Reduced CO_2, thus less climate change	118	39.2%	−10.80% **
Unlike fossil fuels, it cannot be exhausted	86	28.6%	−9.92% *
Low levels of harmful pollution	70	23.3%	−3.39%
The system of feed tariffs is already in place	69	22.9%	11.74% *
Will stimulate regions with low economic activity	67	22.3%	−6.03%
Ease of installation on homes, factories, etc	64	21.3%	−10.97% *
Promote Swiss technology and standing around the world	60	19.9%	−13.29% **
As supply increases, prices will fall	49	16.3%	−24.18% **
The technology has a long life	47	15.6%	−7.41%
Renewable energy is spreading around the world	40	13.3%	−5.79%
It is decentralised and can be efficient at a small-scale	30	10.0%	−8.13%
Other	0	0.0%	-

Notes : 1) ***, **, * indicates that the difference in population ratio is statistically significant at the 1%, 5%, and 10% levels, respectively.

Notes : 2) CH-RU indicates the difference (%) obtained by subtracting the value of the survey results in Russia (RU) from the value of the survey results in Switzerland (CH) (Also in Table 5).

When comparing with responses from the Russian survey, each response was given on average by 5～10% more Russian participants. Thus, 10.8% less Swiss respondents gave reduced carbon emissions as a reason than Russian respondents ; 9.92% less Swiss respondents gave the finite nature of fossil fuels as a reason ; 10.97% less gave ease of installation ; 13.29% less people chose how it would promote Swiss technology to the world. Nearly a quarter (24.18%) more Russians suggested that the price would fall as supply increases. However, 11.74% more Swiss than Russians gave the feed-in tariff as a reason for supporting renewable energy. Briefly, Russians were more likely than Swiss respondents to be concerned about climate change and the finite supply of fossil fuels. In Russia, there are some who see climate change as a positive development, making hostile areas more inhabitable [27]. 60% of Russia is covered by permafrost, and climate change is having dramatic effects on the country. For example, in Yakutsk in eastern Russia, a condominium all but collapsed as the ground underneath it melted [28]. The only issue that saw stronger support amongst the Swiss was on the FIT.

Table 5 shows the reasons for opposing renewable energy and the comparison with the Russian survey. [19]

The most frequently given reason for not supporting renewable energy was higher electricity bills (31.2%). Second was the large number of facilities that would have to be built due to low output, and the expense involved (23.3%). A further 21.9% of participants said the power supply would be unstable, and 16.6% said the technology is not yet developed enough to be worth investing in.

Russian participants were more concerned by the effect of the weather, seasons and time on efficiency (15.32% difference), and the impact it will have on natural landscapes (13.07% difference). They were much less concerned by electricity price increases than Swiss participants (19.39% more Swiss respondents). Looking at the nuclear power generation ratio (EIA [30], 2018) and domestic electricity

Table 5 Reasons for opposing renewable energy (multiple responses possible) and cross-country comparison

item	count	% of total	Country Comparison CH-RU
Increase in electricity bills	94	31.2%	19.39% **
As output is low, large numbers of units will have to be constructed, at great expense.	70	23.3%	－2.07%
Supply is unstable	66	21.9%	－2.74%
Electric storage capacity is still undeveloped	50	16.6%	－3.13%
The full potential of solar and wind energy will never be realised	45	15.0%	－2.81%
Switzerland needs to focus on hydroelectric power	44	14.6%	-
It is too dependent on the weather, seasons and time of day	42	14.0%	－15.32% *
The wildlife, nature and ecosystem around the facility cannot be protected	42	14.0%	－3.15%
Power transmission network is insufficient	40	13.3%	－1.18%
Output is low	36	12.0%	－0.21%
It will have an impact on local natural beauty	28	9.3%	－13.07% *
I am satisfied with my current electricity bill	18	5.98%	－4.22%

prices (DECC [29], 2019) of Switzerland and its neighbours, and those of Japan, it can be seen that : in Germany prices are 33.39 USD/100kWh, with a nuclear power generation ratio of 11.81% ; in Italy with no nuclear power, prices are 28.93 USD/100kWh ; and in Japan 20.20 USD/kWh with 5.0% nuclear power generation. These countries have higher electricity rates than other developed countries. In contrast, France, with 71.33% nuclear power generation, the price is only 19.91 USD/100kWh. However, Switzerland, with 38.44% nuclear power generation has higher.

In Russia, nuclear power generation is lower than Switzerland (17.39%) but even in St. Petersburg in the west, domestic electricity prices (ПЕТРОЭЛЕКТРОСБЫТ [31], 2020) are 6.82 USD/100kWh (Xe, [32]). This is 3.1 times lower than Switzerland, and possibly a reason why Russians are less concerned about any negative impact renewable energy may have on their bills.

4.3 The energy preferences of the Swiss people

Table 6 gives the participants' preferences on power sources, as well as their position on taxation for financing the subsidy and energy conservation.

4.3.1 Hydroelectric power

Since the 19th century, Switzerland has been taking advantage of the abundant water flow coming from the summer thaws, thus fulfilling a large portion of its energy needs. Hydroelectric power generation accounted for 58.44% of energy production in 2017 (EIA). When asked whether the government should further expand hydroelectric power, 40.5% of participants strongly agreed and 34.2% somewhat agreed, for a total of 74.8% supporting further expansion of hydroelectric power.

4.3.2 Solar power

Apart from the recently completed floating solar panel facility on Lake Toules in Bourg-Saint-Pierre in Canton Valais, near the Italian border, large scale solar power facilities are very limited. In 2017, solar power generation only accounted for 2.91% (EIA) of Switzerland's power generation, which is lower than Italy (8.56%), Germany (6.37%) and Spain (5.30%) ; however, it does compare more favorably with the Czech Republic (2.68%) and Denmark (2.46%). Almost three quarters (72.1%) of survey participants agreed that the government should expand solar power further (35.2% strongly agree, 36.9% somewhat agree).

From this, it can be argued that a large majority of Swiss people support natural energy sources such as hydro and solar electricity generation.

4.3.3 Importing electricity

Switzerland is the third largest importer of electricity after the United States (USD 3.078 billion) and Italy (USD 2.252 billion) with USD 1.858 billion (UNCTAD). Asked, in light of this, if the Swiss government should further promote importing of electricity, 68.1% of participants agreed (31.9% strongly, 36.2% somewhat). Switzerland has built up extensive electricity exchange networks with its neighbors (France, Italy, Germany and Austria), has long term contracts with French electricity suppliers which include 2,000MW from French nuclear power plants. These cover Switzerland's frozen winter months, while energy is exported to Italy during the summer. The survey suggests that many participants support continuing and strengthening this network.

Table 6 Preferences for energy source, energy subsidy and power saving taxation (n=301)

Item	Response / Question	strongly agree	somewhat agree	neither	somewhat disagree	strongly disagree	Average SD
Support for hydroelectric	Do you agree the government should expand hydroelectric power generation?	40.5%	34.2%	18.3%	6.0%	1.0%	4.073
		122	103	55	18	3	0.956
Support for solar power	Do you agree the government should expand solar power generation?	35.2%	36.9%	20.3%	6.0%	1.7%	3.980
		106	111	61	18	5	0.973
Support for smart grid	Do you agree the government should develop a smart grid?	26.2%	33.2%	30.2%	6.3%	4.0%	3.714
		79	100	91	19	12	1.048
Support for woody biomass cogeneration	Do you agree the government should expand woody biomass cogeneration?	21.9%	35.2%	28.2%	11.3%	3.3%	3.611
		66	106	85	34	10	1.051
Support for combined cycle power	Do you agree the government should expand combined cycle power generation systems?	18.9%	35.5%	34.2%	8.6%	2.7%	3.595
		57	107	103	26	8	0.977
Support for nuclear power	Do you agree the government should expand nuclear power generation?	23.9%	18.6%	28.6%	13.6%	15.3%	3.223
		72	56	86	41	46	1.359
Support for micro hydroelectric projects	Do you agree the government should expand micro hydroelectric power generation?	11.0%	22.6%	5.3%	20.9%	10.3%	3.030
		33	68	16	63	31	1.135
Item	Response / Question	strongly support	somewhat support	neither	somewhat oppose	strongly oppose	Average SD
Support for energy conservation tax	Do you support a taxation system supporting energy conservation measures?	16.6%	31.9%	31.2%	14.0%	6.3%	3.296
		50	96	94	42	19	1.075
Support for energy tax subsidy	Do you support a tax subsidy system for renewable energy sources?	14.6%	26.9%	37.9%	14.6%	6.0%	3.296
		44	81	114	44	18	1.075

4.3.4 Development of a smart grid

Switzerland's Energy Strategy 2050 includes ending any reliance on fossil fuels [25]. In addition to increasing hydroelectric power generation, this long-term plan intends to expand renewable energy sources and introduce a feed-in tariff system [25]. A smart grid will allow for this system to operate smoothly and efficiently, while directing power to where it is needed most, while also reducing distribution costs [25]. Asked if they agree that the government should invest in such a grid, the largest group (33.2%) said somewhat agree, whereas 30.2% said "neither".

4.3.5 Woody biomass cogeneration

A central pillar of the European Union's efforts towards reducing climate change is the Emissions Trading Scheme (ETS).[7] Under the guidance of the EU and the European Parliament, so far eight coun-

tries have agreed to decommission their coal-fired power station by 2030, with the aim of reducing CO_2 and other greenhouse gas emissions.[8] Within the region, the UK, France and Germany, among others, have committed to abandoning coal as an energy source, and "decarbonizing" has become an international trend [27]. Under these circumstances, it is extremely difficult for Switzerland to support CO_2 emitting thermal power generation, even as it commits to decommissioning all its nuclear power stations. Within the EU, biomass and waste cogeneration is increasing rapidly as it is seen as being carbon neutral. Luxembourg produces 64.75% of its electricity from biomass/waste cogeneration, Denmark 23.22%, Finland 18.86%, the UK 11.32%, Germany 9.42%, and Switzerland only 5.38%.

The Basel-Stadt region in particular has a refuse incinerator that combines with a wood chip burner to provide heating to the nearby area and supplements the electricity generated by the existing power plant [9]. Asked whether they agreed with expanding woody biomass cogeneration, 33.2% said they somewhat agree, and 30.2% responded with neither agree or disagree.

4.3.6 Gas turbine combined cycle

Demand for electricity is highest during the cold winter months, just as the water driving the hydroelectric generators freezes behind the dams. During the 20th century, oil and natural gas imports increased to make up this shortfall. However, the price of commercial-use gas (DECC) is USD 7.35/100kWh (2018). One of the highest in the world. In addition, Switzerland pays USD 56.31 per barrel of crude oil, again one of the highest in the world (OECD). Industrial energy prices are also very high, but thermal power generation only covers 1.24% of their needs (EIA). To help make up this shortfall, gas turbine combined cycle (GTCC) power plants are seen as a viable and sustainable alternative, as they are relatively efficient and produce about 50% less CO_2, NOx and other emissions than traditional fossil fuel power plants. When asked if they agreed the government should further develop GTCC, the largest group of participants said they somewhat agree (33.2%), followed by neither agree nor disagree (30.2%)

4.3.7 Micro hydroelectric power generation projects

In Erstfeld, Canton Uri, in a project with zero environmental impact, electricity is supplied from a system of irrigation canals and small rivers drawn from the Alps, and from roadside drains and gutters [9]. Participants were asked if they agreed that the government should develop more such projects. The most common response (35.2%) said they neither agreed nor disagreed, followed by agreed somewhat (30.3%).

4.3.8 Nuclear power

Although Switzerland has committed itself to abolishing nuclear power by 2034, due to the seasonal nature of its hydroelectric power supply, in 2017 nuclear power still accounted for 33.92% of its electricity generation (EIA). In light of this, participants were asked if the government should continue to support nuclear power. The most common response (28.6%) was neither agree or disagree, succeeded by somewhat agree (18.6%).

4.4 Taxation and subsidy preferences

4.4.1 Background to the introduction of energy conservation taxation and energy subsidy in Switzerland

Before considering the survey results regarding preferences on taxation and subsidies, we will examine the background to their initial introduction.

Takikawa [28] argues that the slow pace of adoption of renewable energy in Switzerland as compared to its neighbours is in large part due to the paucity of the feed-in tariff. It was not until 2009 that Switzerland settled on a fixed rate feed-in tariff system [8]. Renewable electricity in Switzerland is a guaranteed cost purchase scheme, as hoped for by the renewable electricity industry [6]. The Swiss feed-in tariff obliges electricity suppliers to purchase all electricity generated from renewable power producers at a high price that guarantees the cost of generation for 20 years. The feed-in tariffs cover micro-hydro, biomass, solar, and true-phase geothermal power [6]. However, taxation on electricity bills to finance the system was capped at only 0.6 Rappen (EUR 0.04) per kWh, and in fact from 2009, only 0.45 Rappen (EUR 0.03) per kWh was charged in reality. This compares with Germany, where there is no upper limit on the budget. In 2007, the rate was EUR 1.0 per kWh and in 2010 EUR 1.5, more than three times the Swiss charge [28]. In Germany, this higher price for renewable electricity meant that between 2000 and 2007 the annual generation of electricity was equivalent to that of five Swiss nuclear power plants, and the annual generation of electricity from the three sectors of biogas, solar and wind grew sixfold [6]. In Switzerland, it became clear the level of taxation was insufficient to finance the feed-in tariffs, and environmentalists moved quickly to find incomplete projects that would benefit from the feed-in tariff system, and requested the government help fund them from the budget put aside for geothermal power development [8]. According to the Zurich daily newspaper, *Tages-Anzeiger*, the Federal Ministry for Environment, Transport, Energy and Communications agreed with this proposal [8]. In this way, it became possible for the development of renewable energy to continue through additional taxation.

Next, we examine the survey participants' viewpoints on the energy conservation taxation and subsidy system of the Canton of Basel-Stadt (Table 6).

4.4.2 Subsidy and energy conservation tax

The Canton of Basel-Stadt levies an 8% charge on transmission charges, from which it collects CHF 10 million annually. This is used to subsidise renewable energy and energy conservation measures [9]. When asked if they agree such a tax should be implemented throughout Switzerland, 31.9% somewhat agreed and 31.2% were neutral.

In addition to this 8%, there is a steering tax on electricity bills to finance the energy saving bonus all residents and companies are eligible to receive. The incentive is that although everybody receives the same bonus at the end of the year (or same rate if a company), individuals pay less in steering tax by reducing their electricity consumption [9]. The largest response (37.9%) from participants was neither agree or disagree, followed by somewhat disagree (26.9%).

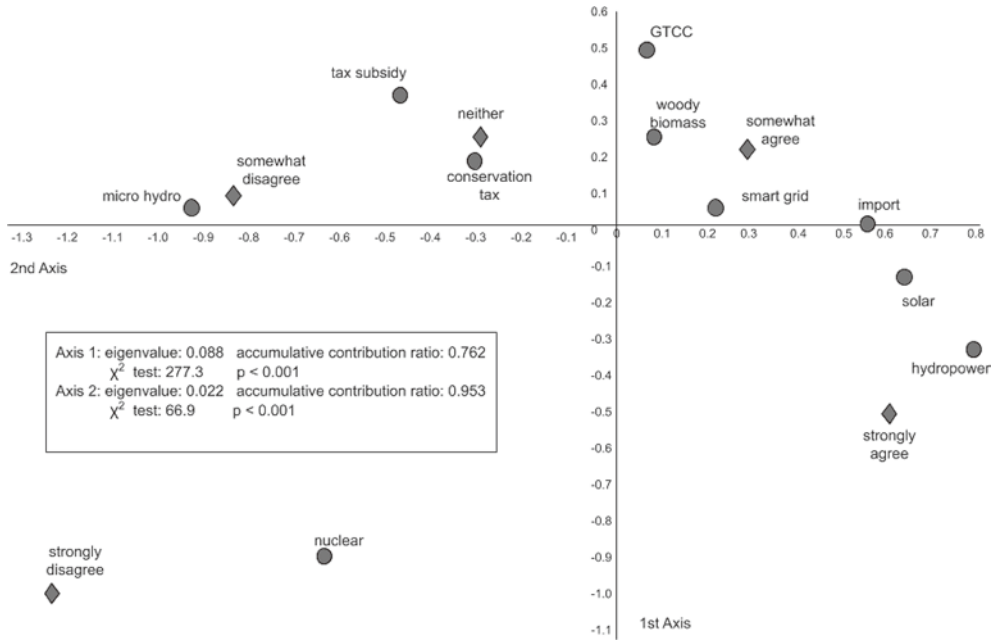
4.5 Correspondence between support for energy taxation/subsidies and support for renewable energy

A correspondence analysis was conducted to illustrate the relation between support for electricity sources and support for subsidies and taxation. This analysis visualizes the relationship between categories using maps. The closer and more aligned items are and the farther out on the map, the stronger the correspondence, the more distant and closer to zero, the weaker the correspondence.

Figure 1 shows the results of this analysis. The vertical axis (1st axis) indicates the support for energy types and is within the range 0.6 to -1.11 ; the horizontal axis (2nd axis) indicates the support for energy taxation and subsidies, and is within the range of 0.8 to -1.3, so the reported values are similar. The 1st axis explains 76.2% of the variance in the data, and the 2nd axis explains 95.3% of the variance, suggesting a close association between the two categories.

In the top right quadrant, combined cycle power generation, wood biomass cogeneration, and smart grid can be found, closely associated with "somewhat agree". In the top left quadrant, support for electricity conservation taxes and subsidies are associated with "neither" ; micro hydropower is close to "somewhat disagree". Nuclear power is located in the bottom left quadrant, as is "strongly disagree". Solar power and hydropower are in the bottom right quadrant, along with "strongly agree". This analysis suggests that a large group of the participants are most enthusiastic about promoting solar and hydroelectric power sources.

Figure 1 Correspondence between subsidy/taxation prefences and support for energy type (Correspondence analysis : frequency)



Source : Datacollected from SurveyMonkey

4.6 Concerns surrounding the installation and management of solar power facilities

The above correspondence analysis suggests that along with hydroelectric power, solar power has strong support among a lot of people. However, many people also have reservations about its introduction.

Table 7 looks at the participants' responses to questions on the installation and management of solar power facilities. First, in the countries neighbouring Switzerland, solar panels are frequently located in solar parks in large open spaces. In Switzerland, in order to protect the natural environment and beauty spots, solar panels are mostly located on big buildings [8]. When asked about the impact of solar panels on the natural environment, the largest group of respondents said they only somewhat agree (32.6%) or

Table 7 Concerns surrounding the installation and management of solar power facilities (n=301)

Item	Response / Question	strongly agree	somewhat agree	neither	somewhat disagree	strongly disagree	Average SD
damage to the natural environment	Do you agree that solar power facilities can damage the natural environment?	20.9%	32.6%	31.9%	10.3%	4.3%	3.555
		63	98	96	31	13	1.065
insufficient local consultation	Do you agree there is insufficient consultation between the construction company and local residents?	15.9%	32.9%	38.9%	7.3%	5.0%	3.475
		48	99	117	22	15	1.008
information sharing by the authorities	Do you agree the authorities do not provide enough information?	14.6%	32.2%	37.9%	8.3%	7.0%	3.392
		44	97	114	25	21	1.058
impact of reflected light	Do you agree light reflected from panels can have a negative impact on the surrounding environment?	14.3%	28.6%	38.5%	13.0%	5.6%	3.329
		43	86	116	39	17	1.053
inadequate management	Do you agree inadequate management can have a negative impact on the neighbourhood?	11.0%	31.6%	36.5%	14.3%	6.6%	3.259
		33	95	110	43	20	1.048
obstruction of natural beauty	Do you agree that solar power facilities can impinge on areas of natural beauty?	13.6%	23.6%	34.9%	17.6%	10.3%	3.126
		41	71	105	53	31	1.165
insufficient technical knowledge	Do you agree that some operators are lacking in technical abilities?	8.3%	28.2%	46.5%	13.0%	4.0%	3.239
		25	85	140	39	12	0.922
out of place with the local scenery	Do you agree the facilities are out of place with the surrounding scenery?	8.6%	24.9%	37.9%	16.6%	12.0%	3.017
		26	75	114	50	36	1.115
electrical fire and panel damage	Do you agree there is a risk of fire, leakage from panels, and other damage due to poor maintenance?	9.6%	23.3%	37.2%	20.3%	9.6%	3.030
		29	70	112	61	29	1.100
abandoned equipment	Do you agree that equipment left behind by defunct operators can be a concern?	6.6%	25.9%	41.5%	16.9%	9.0%	3.043
		20	78	125	51	27	1.027
disaster risk	Do you agree that solar panels might increase the risk of landslides, avalanches or other natural disasters?	8.3%	20.3%	39.5%	22.3%	9.6%	2.953
		25	61	119	67	29	1.070

neither (31.9%).

Installation of solar panels on buildings are regulated by the Building Standards Law, and also tend to come under close scrutiny by nature conservation groups when being installed in mountainous areas [8]. Therefore, when asked if they thought there was a lack of consultation with local residents, a large number of participants said "neither agree or disagree" (38.9%) followed by 32.9% who said they only somewhat agree. Similarly, 38.9% of respondents said neither and 32.2% said somewhat agree to the suggestion that there is insufficient information and communication from the authorities.

On August 24th, 2010, the largest solar panel in Switzerland was installed atop the Federal Institute of Technology in Lausanne. The angle was set so that reflected light did not disturb the university's surrounding environs [8]. On the questions of whether reflected light would negatively impact the surrounding neighbourhood, whether views of areas of natural beauty would be obstructed and whether the facility would be an eyesore, most participants would neither agree or disagree (38.5%, 34.9% and 37.9% respectively), followed by those who agreed somewhat (28.6%, 23.6% and 24.9% respectively).

In neighbouring Germany, the renewable energy sector is one of the most advanced in the world. However, as is often the case with boom industries, solar cell manufacturers have collapsed one after the other, often resulting in employment problems and serious problems for the maintenance of solar power facilities [29]. This has obviously led to concerns about poor business management and lack of technical knowledge. Thus, in response to the questions on inadequate management, insufficient technical knowledge, the risk of fire or other harmful effects due to lack of proper maintenance, and concerns surrounding equipment abandoned by defunct operators, the participants who somewhat agreed that these were issues were, respectively, 31.6%, 28.2%, 23.3% and 25.9% ; sizeable numbers.

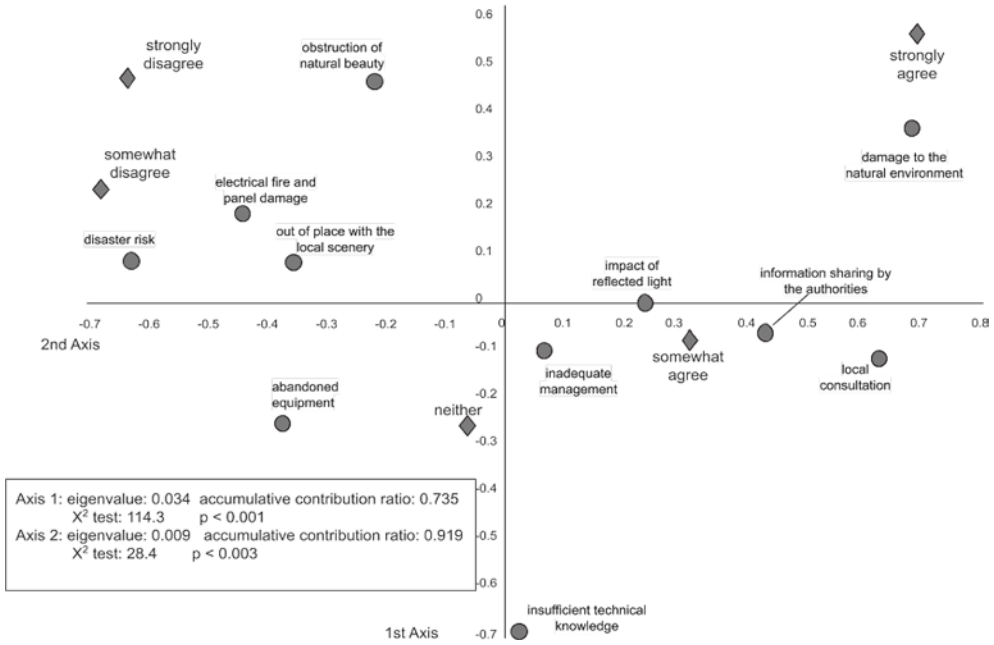
Although Swiss feed-in tariffs and other subsidies are much less generous or expansive as other European countries, the solar power industry has a good reputation for technological development and adaptation to local circumstances [8]. Thus, when asked if they agreed that solar power facilities might result in or contribute to disasters such as landslides or avalanches, most participants remained neutral (39.5%) or somewhat disagreed (22.3%).

4.7 Correspondence of concerns surrounding the installation and management of solar power facilities

Figure 2 gives the results of a correspondence analysis of the relevance of the concerns surrounding the installation and management of solar power facilities. The vertical axis (1st axis) plots the various issues put to the participants, and is within the range of 0.6 to -0.7 ; and the horizontal axis (2nd axis) plots the participants level of agreement, and is within the range 0.8 to -0.7, so the evaluation is comparable. The 1st axis explains 73.5% of variance, and the 2nd axis explains 91.9%. A χ^2 test for both axes reports a p value of 1% or less, indicating they are statistically meaningful.

In the top right quadrant, damage to the natural environment and "strongly agree" are located in similar positions. In the top left quadrant, disaster risk, electrical fire and panel damage, out of place with local scenery, and obstruction of natural beauty, are located along with "strongly disagree" and "somewhat disagree". Abandoned equipment is in the bottom left quadrant, along with "neither agree

Figure 2　Collelation of concerns surrounding the placement of solar power facilities (Correspondence analysis : frequency)



Source : Data collected from SurveyMonkey

nor disagree". The bottom right quadrant insufficient information sharing, the impact of reflected light, inadequate management are clustered around "somewhat agree". This suggests the strongest held concern is over damage to the natural environment, followed by a weaker concern over insufficient information sharing.

4.8 Support for solar power and willingness to pay a surcharge

In this section, we examine (1) if participants support the expansion of solar power energy, how much are they willing to pay in surcharges to support it ; and (2) how much are these same people willing to continue paying a surcharge into the future.

4.8.1 Willingness to taxes to develop solar power capacity

Switzerland has a feed-in tariff system for solar power that is paid for with a surcharge on electricity bills. This was initially CHF 0.003 per kWh, but increased to CHF 0.006 from January 1, 2014 to make up the shortfall [8]. It is highly likely this will have to be increased to finance any expansion of solar power capacity.

Table 8 shows the participants willingness to pay a surcharge in support of solar power capacity expansion.

Among those willing to pay a surcharge, the largest group (19.9%) were willing to pay up to

Table 8 Maximum surcharge participants are willing to pay in support of solar power expansion (n=301)

Item	Response / Question	Willing to pay							Unwilling to pay			Average SD
		CHF 0.008	CHF 0.01	CHF 0.02	CHF 0.03	CHF 0.04	CHF 0.05	CHF 0.06	No need to pay more than CHF 0.006/kWh	Expansion should be paid from current taxation	Other	
electricity bill surcharge	How much of a surcharge are you willing to pay in support of solar power expansion?	19.9%	18.6%	12.6%	11.6%	4.7%	8.0%	3.0%	5.3%	15.6%	0.7%	0.018
		60	56	38	35	14	24	9	16	47	2	0.015

CHF 0.008 per kWh, followed by those willing to pay up to CHF 0.01 (18.6%).

On the other hand, amongst those unwilling to pay any additional surcharges, the majority (15.6% of all participants, 72.3% of those opposed to additional surcharges) believed expansion should be supported from regular taxation. 5.3% of all participants that the status quo of CHF 0.006 per kWh is sufficient.

4.8.2 Willingness to pay taxes in support of renewable energy

In addition to considering increasing the surcharge on electricity bills to support the expansion of solar energy, the Swiss government is also considering increasing taxation to finance the expansion of renewable energy in general. Some proponents argue that the surcharge should be increased to at least CHF 0.02～0.03/kWh [8]. We proposed to the participants that, in order to fund all renewable energy, including solar power, a fund be financed from an additional levy. However, this would not be a consumption tax, but a fixed amount charged to all users on a monthly basis, in addition to the current CHF 0.006/kWh surcharge. They were asked, assuming this system were in place, and how much of a levy would they be willing to pay. Currently, domestic electricity has a basic rate of about CHF 10 per month. For peak hours (Monday to Saturday, 6 : 00am to 10 : 00pm) the rate is about 22.5～24.21 Rappen per kWh, and non-peak hours (outside of those times) the charge is about 13.5～14.53 Rappen.

Table 9 shows the willingness to pay an additional tax burden to finance the expansion of renewable energy.

First of all, among those who are willing to pay the tax burden, the largest group of participants were willing to pay CHF 1 (22.9%), followed by CHF 2.0 (16.6%).

On the other hand, 15.6% of participants said it should be financed by taxation on consumption, not a flat rate levy (52.2% of all those unwilling to pay an additional levy). In addition, 12.6% of participants answered that the status quo is sufficient.

5 Analysis and calculation methodology

In this section we look at whether there is any statistical relationship between the participants' positions facing the challenges of renewable energy and solar power installation, and their personal attributes. Similarly, we look at willingness to pay a surcharge or take on other similar financial burdens in support

Table 9 Willingness to pay an addition levy to finance expansion of renewable energy (n=301)

Item	Response / Question	Willing to pay						Unwilling to pay				Average SD
		CHF 1.0	CHF 2.0	CHF 3.0	CHF 4.0	CHF 5.0	CHF 6.0	No need to pay more than CHF 0.006/kWh	Expansion should be paid for according to consumption	Expansion should be paid from other taxation	Other	
renewable energy levy	How much are you willing to pay in addition to the current surcharge in support of renewable energy?	22.9%	16.6%	13.3%	6.3%	6.3%	4.7%	12.6%	15.6%	1.7%	0.0%	1.809
		69	50	40	19	19	14	38	47	5	0	1.758

of renewable energy, and personal attributes.

5.1 Analysis methodology

5.1.1 Analysis of knowledge about French nuclear accidents and trust in the statements of the French authorities, and support for renewable energy and willingness to finance subsidies

First, an ordinal logit model was used to model the items "French radioactive leak" and "Trust in French authorities' statements" (see Table 2) as the dependent variables. So, for example, on the question of "how aware are you of radioactive leaks in French nuclear power plants?" the categories are "unaware"=1, "not so aware"=2, "neither"=3, "somewhat aware"=4 and "very aware"=5.

A second ordinal logit model was used to model support for energy type and support for energy surcharge/subsidy (see Table 6) as the dependent variables. So, for example, taking "support for hydroelectric", the categories are "strongly disagree"=1, "somewhat disagree"=2, "neither"=3, "somewhat agree"=4 and "strongly agree"=5.

Seven individual attributes have been used as explanatory variables. The three qualitative variables gender (male=1, female=0), and region (Zürich, Genève, Vaud, Bern, Basel-Stadt Territory=1, all other states=0), the presence of children under 12 in the household (present=1, absent=0) are all dichotomous variables.

The four quantitative variables are age, household size, education, and salary. Age and salary are continuous or interval variables (for example a 45 year old falls into the 40～50 age range, a salary of CHF 5,500 CHF 5,001～6,000 salary range). Education is classed as a continuous variable, scoring 1 for high school to 4 for post graduate.[9]

In the event that the differences between the categories of the dependent variables were not statistically significant or if the responses were too few, the results were combined. The estimate gives only the optimal value suggested by applying the AIC and the relative likelihood ratio test. For each independent variable, the backward selection method was applied to eliminate those variables above the 20% significance level, and only those variables that were significant at the 1-10% level were considered for the calculation. In the table below, cut indicates a threshold variable, which corresponds to Pr (y = 1) = Pr

($\beta x <$cut1), Pr (y = 2) = Pr (cut1 $<\beta x <$cut2) (where y is the category of the dependent variable, x is the explanatory variable, and β is the parameter).

5.1.2 Analysis of changes in attitudes to energy policy and challenges facing solar power

We applied the ordinal logit model to the question of changes in preferences on energy policy after the Fukushima accident (Table 2) as the dependent variable. The categories are "no change at all"=1, "minor change"=2, "neither"=3, "somewhat changed"=4 and "large change"=5.

We also looked at concerns surrounding the installation and management of solar power facilities (Table 7) as a dependent variable. The categories are "strongly disagree"=1, "somewhat disagree"=2, "neither"=3, "somewhat agree"=4, "strongly agree"=5. The above mentioned individual attributes are the independent variables.

5.1.3 Analysis of support for renewable energy

In order to fully understand the factors behind support for renewable energy (Table 2), we apply a sequential logit model and also calculate the marginal effect.

The dependent variable is "strong support for fossil fuels"=1, "minor support for fossil fuels"=2, "neither"=3, "somewhat support for renewable energy"=4 and "strong support for renewable energy"=5.

Additional dependent variables from Table 4 (Reasons for supporting renewable energy) were added into the formula. Only results scoring above 20% were included.

5.1.4 Analysis of willingness to pay in support of solar power and renewable energy

Finally, the tobit model was applied to participants' willingness to pay additional tariffs or levies for the expansion of solar and renewable energy.

The dependent variable was "electricity bill surcharge" (Table 8), and only dependent variables scoring a significance of 20% or below were included in the model.

For both of these models, the independent variables are the above mentioned seven personal attributes.

5.2 Analysis results

5.2.1 Knowledge of nuclear accidents, trust in government statements, and support for energy sources and taxation/subsidy

Table 10 gives the estimated results regarding knowledge of nuclear accidents, trust in government statements, support for various energy sources, and support for energy conservation taxes and subsidies for renewable energy. The pseudo R^2 is as low as 0.005 to 0.025 ; but, where the regression coefficient is zero using the likelihood ratio test for the null hypothesis, data is excluded from the table. All five categories of the dependent variables were applied, but as the differences were not statistically significant, the first to third categories were integrated into cut 1. The marginal effect has been omitted due to space limitations.

First, looking at those who "support nuclear power", the male coefficient (0.837) returns a positive value, indicating that most support for nuclear power came from male participants. On the other hand, the male coefficient for support for taxes to finance subsidies (-0.429) returns a negative value, indicating

Table 10 Knowledge of nuclear power plant accidents, trust in information disclosure, support for conservation and subsidy taxes (Results of Estimated Order Logit Model)

Variable	*Knowledge of French radioactive leaks*			*Trust in French authorities' statements*			*Support for hydropower*			*Support for imported power*			*Support for smart grid*		
	coef.	Std. err.	p value	coef.	Std. err.	p value	coef.	Std. err.	p value	coef.	Std. err.	p value	coef.	Std. err.	p value
male=1	0.313	0.213	0.142												
age	0.013	0.008	0.098 *	−0.020	0.009	0.022 **				0.019	0.008	0.019 **			
Bern	−0.472	0.333	0.156												
Vaud	0.562	0.355	0.113												
household size	−0.153	0.096	0.112							−0.191	0.090	0.033 **	−0.151	0.086	0.078 *
children	0.386	0.256	0.131				−0.339	0.225	0.131						
education				−0.304	0.102	0.003 ***	0.320	0.082	0.000 **	0.274	0.091	0.003 ***	0.284	0.085	0.001 ***
salary				0.000	0.000	0.016 **	0.004	0.002	0.071 *						
cut 1	0.671	0.420	0.110	3.381	0.570	0.000 ***	1.459	0.333	0.000 ***	1.646	0.513	0.001 ***	1.639	0.356	0.000 ***
cut 2	−0.448	0.415	0.281	1.966	0.542	0.000 ***	−0.092	0.280	0.743	−0.415	0.475	0.383	−0.187	0.326	0.567
cut 3	−1.818	0.429	0.000 ***	0.790	0.524	0.132	−1.648	0.303	0.000 ***	−2.006	0.489	0.000 ***	−1.657	0.343	0.000 ***
likelihood ratio	814.9 *			789.4 ***			720.4 **			733.9 ***			778.8 ***		
AIC	832.9			801.4			732.4			745.9			788.8		
χ^2	12.4			20.2			19.7			19.0			11.6		
pseudo R^2	0.015			0.025			0.027			0.0252			0.015		

Variable	*Support for woody biomass cogeneration*			*Support for GTCC*			*Support for nuclear power*			*Support for energy conservation taxes*			*Support for energy tax subsidy*		
	coef.	Std. err.	p value	coef.	Std. err.	p value	coef.	Std. err.	p value	coef.	Std. err.	p value	coef.	Std. err.	p value
male=1	0.333	0.209	0.111				0.837	0.214	0.000 ***				−0.429	0.208	0.039 **
Zürich															
Bern	−0.559	0.335	0.095 *	0.575	0.277	0.038 **									
Vaud															
Age				−0.646	0.355	0.069 *	−0.025	0.008	0.001 ***						
education							−0.176	0.087	0.043 **						
salary	0.242	0.083	0.004 ***				0.004	0.002	0.075 *	0.004	0.002	0.037 **			
cut 1	0.865	0.331	0.009 ***	2.054	0.195	0.000 ***	1.919	0.400	0.000 ***	1.137	0.180	0.000 ***	1.576	0.182	0.000 ***
cut 2	−0.636	0.315	0.044 **	0.147	0.132	0.265	0.627	0.384	0.103	−0.302	0.163	0.064 *	−0.119	0.155	0.444
cut 3	−2.244	0.342	0.000 ***	−1.524	0.164	0.000 ***	−0.295	0.392	0.451	−1.877	0.202	0.000 ***	−1.551	0.190	0.000 ***
likelihood ratio	790.9 ***			771.2 **			793.1 ***			808.1 **			793.0 **		
AIC	802.9			781.2			807.1			816.1			801.0		
χ^2	12.3			9.0			30.2			4.4			4.2		
pseudo R^2	0.015			0.012			0.037			0.005			0.005		

Notes : 1) ***, **, * indicates statistical significance at 1%, 5% and 10% respectively (applicable to Tables 11 to 13)

Notes : 2) cut combines "somewhat disagree" and "strongly disagree" (applicable for Tables 12 and 13)

Notes : 3) All seven individual attributes were applied in the model, but using the backward selection method, variables above the 20% significance level were excluded, and only variables that were significant at 1～10% were used in orde to get the optimum results (applicable to Table 11)

Notes : 4) In addition to the above variables, "knowledge of the Chernobyl nuclear accident", "trust in Russian authorities' statements" and "support for micro hydropower" (Table 6) were also calculated, but due to the results of the likelihood ratio test, they have been excluded.

men are opposed to such a policy.

Next, there are some regional differences appearing in the model. For example, there is no support for woody biomass cogeneration in the Canton of Bern (-0.559). In Zürich, there is support for combined cycle gas turbines (0.575), but not in Vaud (-0.559).

Not surprisingly, "knowledge of French nuclear power accidents" show positive values for older participants (0.013), as does "support for imported power" (0.019). On the other hand, "trust in French authorities' statements" and "support for nuclear power" give negative age coefficients (-0.020 and -0.025 respectively) indicating lower age groups.

Household size had negative coefficients for support for imported electricity and development of a smart grid (-0191 and -0151), indicating that participants giving positive responses had smaller or no immediate family. Education, on the other hand, returned positive results (0.274 and 0.284 respectively), suggesting the more highly educated supported these options.

The level of education also appears to influence support for hydropower (0.320) and woody biomass cogeneration (0.242), but has a negative correlation with "trust in French authorities' statements" (-0.304) and support for nuclear power (-0.176), suggesting those with higher educational levels are more skeptical of these variables.

Finally, the income of those with "trust in French authorities' statements" was slightly higher (0.000), as was support for the status quo, as indicated by their support for hydropower (0.000) and nuclear power (0.004). However, "support for energy conservation taxes" was also higher with higher income groups (0.004).

5.2.2 Energy policy preference changes, support for solar power, and solar power concerns

Table 11 gives the estimated correlations of changes in energy policy preferences, support for solar power and concerns surrounding solar power facilities.

Firstly, those who felt their energy policy preferences had changed the most were residents of Zürich (0.545) and Genève (0.843), whereas the strongest support for solar power was in Basel-Stadt (1.269). It was also correlated with higher levels of education and higher levels of income (0.163 and 0.004 respectively).

Residents of Zürich were the most concerned about "inadequate management" of solar power facilities (0.532), whereas residents of Genève showed concern for "insufficient local consultation" by operators and "inadequate management" (1.089 and 1.007 respectively). In Switzerland, there are three international and two large regional power companies.[10] The two regional companies are EWZ (Elektrizitätswerk der Stadt Zürich) in Zürich and SIG (Services Industriels de Genève) in Genève, and both have full, vertical integrated control of the industry within their cantons, from production to household distribution [25]. SIG is taking a leading role in the expansion of renewable energy, and EWZ reported an increase of 779 households with solar panels in 2012 to 3,190 in 2017 [30]. Along with the other cantons, residents of Genève and Zürich are, while increasingly supportive of renewable energy, somewhat cautious about what is still seen as a new and not fully tested energy source, and are reluctant about installing solar power.

In the Canton of Vaud, where Switzerland's largest solar power installation can be found, concerns

Table 11 Energy policy preference change, support for solar power, and concerns surrounding solar power facilities (Results of Estimated Order Logit Model)

Variable	*changes in energy preferences*			*destruction of the natural environment*			*insufficient local consultation*			*impact of reflected light*			*inadequate management*		
	coef.	Std. err.	p value	coef.	Std. err.	p value	coef.	Std. err.	p value	coef.	Std. err.	p value	coef.	Std. err.	p value
age				−0.014	0.008	0.068 *							−0.014	0.008	0.090 *
Zürich	0.545	0.272	0.045 **										0.532	0.272	0.050 *
Genève	0.843	0.400	0.035 **				1.089	0.392	0.006 *				1.007	0.398	0.011 **
Vaud										−0.780	0.362	0.031 **			
household size	−0.116	0.086	0.177							−0.268	0.094	0.004 ***			
children										0.392	0.250	0.117			
salary				0.003	0.002	0.119							−0.004	0.002	0.051 *
cut 1	1.961	0.287	0.000 ***	2.174	0.370	0.000 ***	1.908	0.177	0.000 ***	2.150	0.274	0.000 ***	2.010	0.392	0.000 ***
cut 2	0.404	0.258	0.117	0.531	0.345	0.124	−0.131	0.119	0.274	0.337	0.240	0.160	0.309	0.372	0.406
cut 3	−1.092	0.266	0.000 ***	−0.960	0.351	0.006 ***	−1.780	0.166	0.000 ***	−1.198	0.261	0.000 ***	−1.541	0.391	0.000 ***
likelihood ratio	799.2 **			800.4 *			764.9 ***			780.0 ***			766.6 ***		
AIC	811.2			810.4			772.9			792.0			780.6		
χ^2	9.2			5.3			7.8			12.4			17.0		
pseudo R^2	0.011			0.007			0.010			0.016			0.022		

Variable	*support for solar power*			*obstruction of natural beauty*			*electrical fire and panel damage*			*abandoned equipment*			*disaster risk*		
	coef.	Std. err.	p value	coef.	Std. err.	p value	coef.	Std. err.	p value	coef.	Std. err.	p value	coef.	Std. err.	p value
age				−0.018	0.007	0.015 **	−0.023	0.007	0.001 ***				−0.021	0.007	0.002 **
Vaud							−0.961	0.367	0.009 ***	−0.633	0.345	0.067 *	−0.761	0.369	0.039 **
Basel-Stadt	1.269	0.719	0.077 *												
education	0.163	0.081	0.044 **	−0.194	0.087	0.025 **									
salary	0.004	0.002	0.059 *												
cut 1	1.694	0.329	0.000 ***	2.345	0.371	0.000 ***	1.879	0.297	0.000 ***	1.127	0.139	0.000 ***	1.674	0.295	0.000 ***
cut 2	0.135	0.280	0.629	0.832	0.347	0.016 ***	0.247	0.271	0.362	−0.667	0.126	0.000 ***	−0.050	0.271	0.853
cut 3	−1.467	0.299	0.000 ***	−0.508	0.365	0.165 *	−1.307	0.310	0.000 ***	−2.591	0.233	0.000 ***	−1.554	0.317	0.000 ***
likelihood ratio	744.9 **			793.8 ***			762.8 ***			746.1 *			747.8 ***		
AIC	756.9			803.8			772.8			754.1			757.8		
χ^2	10.9			10.4			15.9			3.4			11.7		
pseudo R^2	0.014			0.013			0.020			0.005			0.015		

Notes : In addition to the above variables, “information sharing by the authorities”, “insufficient technical knowledge” and “out of place with the local scenery” (Table 6) were also calculated, but due to the results of the likelihood ratio test, they have been excluded.

over the “impact of reflected light”, “electrical fire and panel leakage”, “abandoned equipment” and “disaster risk” were very negatively correlated (-0.780, -0.961, -0.633, and -0.761 respectively), suggesting the participants were not concerned with any of these issues.

Concerns over “destruction of the natural environment”, “inadequate management”, ”obstruction of

natural beauty", "disaster risk" and "electrical fire and panel damage" had very little correlation with younger participants (-0.014, -0.014, -0.018, -0.023, and -0.021 respectively).

Concern over "obstruction of natural beauty" was higher amongst people with lower levels of education (-0.194), and only a very few with high levels.

Finally, those who showed the most concern over "inadequate management" tended to have lower incomes (-0.004), and only a very few in higher income brackets.

5.2.3 Estimated results of correlation and marginal effects of support and opposition to renewable energy

Table 12 shows the correlation and marginal effects on support and opposition to renewable energy.

First of all, looking at the regression coefficients for "reduced CO_2, thus less climate change" (1.018), "unlike fossil fuels, it cannot be exhausted" (0.437), "low levels of harmful pollution" (0.424), "will stimulate regions with low economic activity" (0.393), and "renewable energies are spreading around the world" (0.354), all have positive values.

On the other hand, the only variable opposing renewable energy with a positive coefficient is "as output is low, large numbers of units will have to be constructed, at great expense" (0.273), indicating this is the main reason for opposing renewable energy amongst the participants. These are the statistically significant reasons for supporting renewable energy. Comparing these results with the Russian survey [19], it can be seen that similar results are produced, such as "reduced CO_2, thus less climate change", "low levels of harmful pollution", and "unlike fossil fuels, it cannot be exhausted", which were the three statistically significant variables from that study.

Other options for opposing renewable energy all gave negative values : "the full potential of solar and wind energy will never be realized" (-0.343), "I am satisfied with my current electricity bill" (-0.512), and "it is too dependent on the seasons, weather and time of day" (-0.390).

Next, the results for the marginal effect. The marginal effect was calculated for "strongly oppose" + "somewhat oppose" renewable energy, "neither" support or oppose, "somewhat support", and "strongly support" renewable energy.

After calculating marginal values for all the above, "strongly support" renewable energy gave the largest absolute value. Therefore, only this value will be examined in detail below.

The variable "reduced CO_2, thus less climate change" had the largest marginal effect (0.389), followed by "unlike fossil fuels, it cannot be exhausted" (0.173). These results mirror the Russian survey, which reported similar marginal effects for these two variables.

The other variables had slightly weaker marginal effects : "low levels of harmful pollution" (0.168), "will stimulate regions with low economic activity" (0.156), "renewable energies are spreading around the world" (0.140), and "as output is low, large numbers of units will have to be constructed, at great expense" (0.108).

On the other hand, the variables with the largest negative marginal effects were "I am satisfied with my current electricity bill" (-0.191), "it is too dependent on the seasons, weather and time of day" (-0.150) and "the full potential of solar and wind energy will never be realized" (-0.133).

Table 12 Estimation of the correlation and marginal effect between reasons for supporting or opposing renewable energy (sequential logit model)

variable	support for renewable energy			strongly + somewhat opposed			neither			somewhat support			strongly support		
	Coef.	Std. err.	p value	dy/dx	Std. err.	p value	dy/dx	Std. err.	p value	dy/dx	Std. err.	p value	dy/dx	Std. err.	p value
Reduced CO_2, thus less climate change	1.018	0.151	0.000 ***	−0.047	0.014	0.001 ***	−0.194	0.030	0.000 ***	−0.148	0.032	0.000 ***	0.389	0.053	0.000 ***
Unlike fossil fuels, it cannot be exhausted	0.437	0.156	0.005 ***	−0.019	0.007	0.013 **	−0.087	0.030	0.004 ***	−0.068	0.029	0.019 **	0.173	0.061	0.004 ***
Low levels of harmful pollution	0.424	0.179	0.018 **	−0.017	0.008	0.025 **	−0.083	0.032	0.009 ***	−0.068	0.035	0.050 *	0.168	0.070	0.016 **
Will stimulate regions with low economic activity	0.393	0.176	0.026 **	−0.016	0.007	0.028 **	−0.077	0.032	0.017 **	−0.063	0.033	0.061 *	0.156	0.069	0.024 **
Renewable energy is spreading around the world	0.354	0.213	0.097 *	−0.014	0.007	0.060 *	−0.068	0.037	0.066 *	−0.058	0.042	0.163	0.140	0.083	0.093 *
As output is low, large numbers of units will have to be constructed, at great expense.	0.273	0.167	0.102	−0.012	0.007	0.092 *	−0.055	0.032	0.088 *	−0.041	0.029	0.151	0.108	0.066	0.101
The full potential of solar and wind energy will never be realised	−0.343	0.186	0.066 *	0.022	0.016	0.166	0.078	0.045	0.081 *	0.033	0.013	0.015 **	−0.133	0.069	0.056 *
Satisfied with current electricity bill	−0.512	0.269	0.057 *	0.041	0.032	0.203	0.120	0.067	0.072 *	0.031	0.013	0.021 **	−0.191	0.091	0.036 **
It is too dependent on the weather, seasons and time of day	−0.390	0.211	0.060 *	0.026	0.019	0.171	0.089	0.051	0.083 *	0.035	0.013	0.008 ***	−0.150	0.077	0.053 *
cut 1	−1.352	0.159													
cut 2	−0.227	0.122													
cut 3	0.792	0.127													
likelihood ratio	−307.4 ***														
χ^2	91.1														
pseudo R^2	0.129														

Note : In the calculation, the results from Table 4 (Reasons for supporting renewable energy) and Table 5 (Reasons for opposing renewable energy) were used. Using the backward selection method, variables scoring over 15% were removed. All remaining variables are significant at the 1~10% level. (Applicable to Table 13)

5.2.4 Estimating willingness to pay for solar power and renewable energy

Table 13 gives the results of a tobit analysis of the willingness of participants to pay for solar power and renewable energy, and their personal attributes. In the tobit model, thresholds are set, so that if the variable exceeds the value, it only reports the maximum or minimum value set by the threshold. In this paper, it is applied to the participants who indicated no intention to pay any additional taxes (see Tables 8 and 9).

First, the coefficient for “willingness to pay for solar power” gives a positive value (0.0002) for age, meaning older people are more willing to pay additional taxes.

On the other hand, age returns a negative value for “willingness to pay for renewable energy”

Table 13 Willingness to pay for solar power and renewable energy (tobit model)

Variable	*willingness to pay additional taxes for expansion of solar power*			*willingness to pay additional taxes for expansion of renewable energy*		
	coef.	standard error	p value	coef.	standard error	p value
age	0.0002	0.000	0.026 **	− 0.023	0.010	0.020 **
Basel-Stadt				1.012	0.695	0.146
education				0.209	0.104	0.046 **
constant term	0.0069	0.003	0.046 **	2.205	0.525	0.000 ***
likelihood ratio	616.2 **			477.6 **		
χ^2	5.0			10.3		
pseudo R^2	− 0.004			0.011		

Notes : 1) ***, **, * indicates statistical significance at 1%, 5% and 10% respectively (applicable to Tables 11 to 13)

Notes : 2) cut combines "somewhat disagree" and "strongly disagree" (applicable for Tables 12 and 13)

Notes : 3) All seven individual attributes were applied in the model, but using the backward selection method, variables above the 20% significance level were excluded, and only variables that were significant at 1～10% were used in orde to get the optimum results (applicable to Table 11)

Notes : 4)In addition to the above variables, "knowledge of the Chernobyl nuclear accident", "trust in Russian authorities' statements" and "support for micro hydropower" (Table 6) were also calculated, but due to the results of the likelihood ratio test, they have been excluded.

(-0.023) suggesting younger people are more willing to take on an additional tax burden to expand renewable energy.

In other words, older people tended to oppose the introduction of a flat rate levy of approximately CHF 10 to help finance renewable energy, despite their willingness to pay a surcharge in support of solar power. However, the positive coefficient for education (0.209) indicates that those with higher levels of education showed a higher level of willingness to pay a levy.

6. Conclusions

In this paper, we examined the case of Switzerland as an example of a country withdrawing from nuclear power and moving towards a next-generation energy strategy. The following points can be obtained from our research.

Having experienced the Chernobyl nuclear accident, and worried over repeated accidents in neighbouring France, the Fukushima accident was a deciding factor for many Swiss people. A majority of people see their country's energy policy has changed, and favour a continued shift in policy towards renewable energy sources. Residents of Zürich and Genève in particular reported a strong awareness of the shift in energy policy.

Although Switzerland currently has the lowest level of renewable energy in Western Europe, it ful-

fills a lot of its energy needs from its hydroelectric capacity, and is also increasingly aware of the need for solar power and other renewable energy sources. The need for flexibility is seen as a necessity. It is utilizing imported power from neighbouring countries, and in the French speaking areas, especially Zürich, combined cycle power generation is seen as an opportunity, and in Lausanne solar power is increasingly popular.

Amongst our survey participants, the biggest concern regarding solar power facilities was the potential damage to the natural environment. In addition, the lack of sufficient communication between the local residents and the operators and also the government authorities, reflected light and improper management of the facilities were seen as important issues. In the Canton of Genève, where the construction of power plants was banned after Chernobyl, there was concern about solar power facilities having poor management or exacerbating a natural disaster, but in Vaud, home of Switzerland's largest solar power plant, there was widespread support.

The main reasons for supporting renewable energy were combating climate change and reducing pollution. As with Russia, the introduction of a feed-in tariff was given as a reason for supporting solar and renewable energy. On the other hand, the main reason for opposing renewable energy was the worry of increased electricity bills. In comparison with Russia, the concern of the Swiss was that one of the world's most expensive electricity charges might get even higher.

Switzerland has already introduced a feed-in tariff system for solar power ; however, the fund is poorly financed and further financing from some form of taxation is needed. Older generations were willing to pay extra taxes while the increases were small, but proved unwilling to pay as the potential taxes increased. Higher levels of education corresponded with willingness to pay higher taxes. It was also seen as important to fully communicate the advantages and disadvantages of having solar power facilities with local residents before installation.

Due to unforeseen circumstances unconnected with the research, there was a delay in publication, during which the Russian invasion of Ukraine occurred. Therefore, it should be noted that this paper does not reflect changes in the energy situation due to the invasion of Ukraine.

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Notes

1 In May 2008, the Swiss government introduced the feed-in tariff for solar power, but it was structured to benefit the existing large-scale electricity companies rather than individual households and farmers [9]. Due to the enormous potential of solar power generation, vested interests took steps to prevent the widespread adoption of solar power amongst the general public [9]. See Takikawa [9] for details on the implementation of the feed-in tariff system in Switzerland.

2 A Swiss study conducted in 2013 found that sediment in Lake Biel had accumulated cesium-137 between 1950 and 2013 ; one eighth was from the Chernobyl fallout, the remainder from testing in the 1960s at the Mühleberg Nuclear Power Plant [8].

3 During the heat wave that swept across Europe of 2019, the French authorities and operators decided to close the two Golfech nuclear power plants between 23 to 30 July 2019 [23]. Similarly, the German Lower Saxony authorities announced the Grondé nuclear power plant would be closed 25 July to 26 October [24].

4 34 years after the Chernobyl accident, traces of cesium-137 is still being found in some valleys in the Cantons of Ticino and Graubünden [8].

5 The average age in 2020 is 43.05 (UN). The proportion of under-15 year-olds in 2018 was 14.91%, 15 to 64 year-old 66.47% and over 65 was 18.62% (World Bank). The average age distribution of our survey participants is slightly younger.

6 The percentage of university graduates (four-year colleges) is 55.20% (OECD 2017) ; this survey has a large number of junior college and specialist schools.

7 The EU ETS Phase I (2005-2007) included 15 EU members, while Norway, ICeland, Liechtenstein and other non-EU member states, including Switzerland, joined in Phase II (2008-2012) [26].

8 France will abolish coal-fired power generation by 2022, Italy and Ireland by 2025, and Spain, the Netherlands, Denmark, Portugal, and Finland by 2030 [26].

9 We used a discrete variable as a proxy variable for the number of years of education completed.

10 The Alpiq Group supplies about one-third of Switzerland's electricity, mainly from domestic hydropower [25]. Axpo Holding AG is owned by the north-eastern cantons of Switzerland, and produces 40% of Switzerland's nuclear power and 25% of its hydroelectric power [25]. BKW FMB Energie AG focuses on hydroelectric and nuclear power, but has recently expanded into solar and wind power generation [25].

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