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Views of the informed citizen panel to Enhanced Geothermal Systems vs. other electricity generation alternatives in Switzerland

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ABSTRACT

Decision science literature argues that conventional opinion surveys are limited for making strategic decisions because the elicited opinions may be distorted by misconceptions and awareness gaps that prevail in the public. Such distortions are in particular expected for new technologies, such as Enhanced Geothermal Systems (EGS). We created an informed citizen panel (N=46) for understanding the preferred Swiss electricity mix in 2035, given the information about environmental, health, economic and accident impacts of various electricity generation technologies. We used technology factsheets, an interactive web-tool Riskmeter, and group discussions for informing the participating citizens. We then measured the evolution of the panel's knowledge and preferences from initial (uninformed) to informed and longer-term views four weeks after. For EGS, we found that the participants were in particular sensitive to new information as they did not yet have stable opinions formed and, in fact, with more information the opinions worsened. Induced seismicity risk was one of the elements that was used by our participants in their opinion formation, but also land use, climate, and electricity supply reliability impacts as well as the overall comparison with other technologies. We also found structurally different pattern in the evolution of opinion for EGS and other renewable electricity generation alternatives. We thus conclude with implications of these findings for understanding the public preferences for EGS and for communicating about it.

1. INTRODUCTION

Opinion surveys are widely used in order to elicit public views and preferences to energy technologies (Bertsch et al., 2016; Knoblauch et al., 2019; Pidgeon et al., 2008; Visschers and Siegrist, 2014). Decision science literature argues that conventional opinion surveys are limited for making strategic decisions because the elicited opinions may be distorted by misconceptions and awareness gaps that prevail in the public (Fleishman et al., 2010; Morgan et al., 2002; Wong-Parodi et al., 2016). Such distortions are in particular expected for new technologies, such as Enhanced Geothermal Systems (EGS). For example, Volken et al. (2019) conducted open-ended interviews with non-expert respondents in Switzerland and showed that non-experts tended to mix up EGS with heat pumps (e.g. "Enhanced Geothermal System … they can install that at your house, right?" [ID 10]) or they misperceived the possible impacts (e.g. "Yes, it could lead to a small vulcanic eruption" [ID 7]). Although opinion surveys are generally useful, they are incomplete guides for strategic long-term decision making because they are distorted by unfamiliarity and misconceptions.

In order to better understand the similarities and differences between conventional opinion surveys and informed views of the public, we created an informed citizen panel (N=46) for understanding the preferred Swiss electricity mix in 2035. We measured the evolution of the panel's knowledge and preferences from initial (uninformed) to informed and longer-term views four weeks after. Among other electricity generation technologies, we also included EGS. In this conference paper, we present the overall findings of the study and especially discuss the implications for EGS.

2. METHODS

We created an informed citizen panel (N=46) in the German-speaking part of Switzerland to elicit the informed public preferences for the Swiss electricity mix 2035, given information about the multi-dimensional environmental, health, and economic impacts, as well as accident risks of various electricity generation technologies. Figure 1 shows the procedure that was developed for this purpose (Volken et al., 2018). The participants were recruited throughout May 2017 by advertising the study on online platforms and in various public places. 55 participants then received a workshop invitation letter with printed factsheets on electricity technologies and their impacts (Trutnevyte et al., 2019) and a request to spend up to an hour reading these factsheets. Four workshops that lasted 2.5 hours and involved 8–15 participants were organized. 46 participants eventually showed up. After the introduction of the workshops, the participants discussed the individual electricity technologies and their learnings from the factsheets in two sub-groups facilitated by a moderator. After this discussion, the moderator introduced the interactive web-tool Riskmeter (University of Geneva, 2019), where the participants could build and submit a preferred electricity supply mix for Switzerland in 2035. After the Riskmeter submissions, the participants again had a group discussion and the workshops were concluded. During the whole process, from before the factsheets to four weeks after the workshops, the participants received a series of surveys that measured the evolution of their knowledge and preferences for electricity generation technologies, the Swiss electricity mix as a whole, technology impacts, and other indicators. The full list of indicators is provided by Volken et al. (2018).

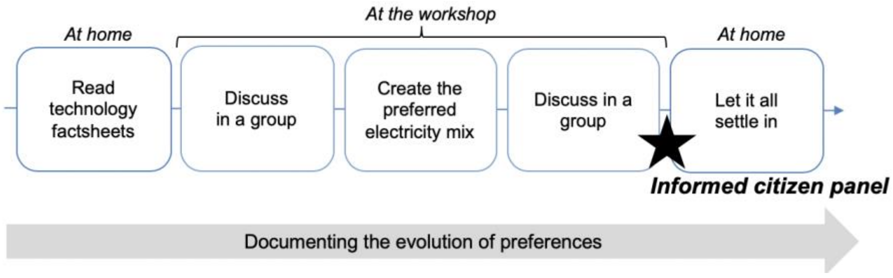

Figure 1: Process of creating an informed citizen panel. Volken et al. (2018) provide a detailed description.

The informational factsheets described 13 alternatives that could contribute to the Swiss electricity mix in 2035 (Figure 2): (1) three hydropower types, including large dams, large run-of-river, and small hydropower; (2) five new renewable technologies—solar cells (photovoltaic), wind, deep geothermal (EGS), woody biomass, and biogas; (3) nuclear power, (4) waste incineration and large natural gas power plants, (5) net electricity import from abroad (net on the annual basis), and (6) electricity savings and efficiency improvements to reduce the electricity demand. Each technology, its current status, resource potential, and environmental, health, and economic impacts were described qualitatively and quantitatively on a double-sided A4 paper. The impacts included climate change (CO_{2eq}), local air pollution ($PM10_{eq}$, SO_x and NO_x), water, landscape and land use (m^2 of land use), flora and fauna, accidental impacts, resource use and waste (kWh of non-renewable energy used for 1 kWh of electricity), electricity costs (Rp. per kWh), and electricity supply reliability. The factsheets are available online (Trutnevyte et al., 2019).

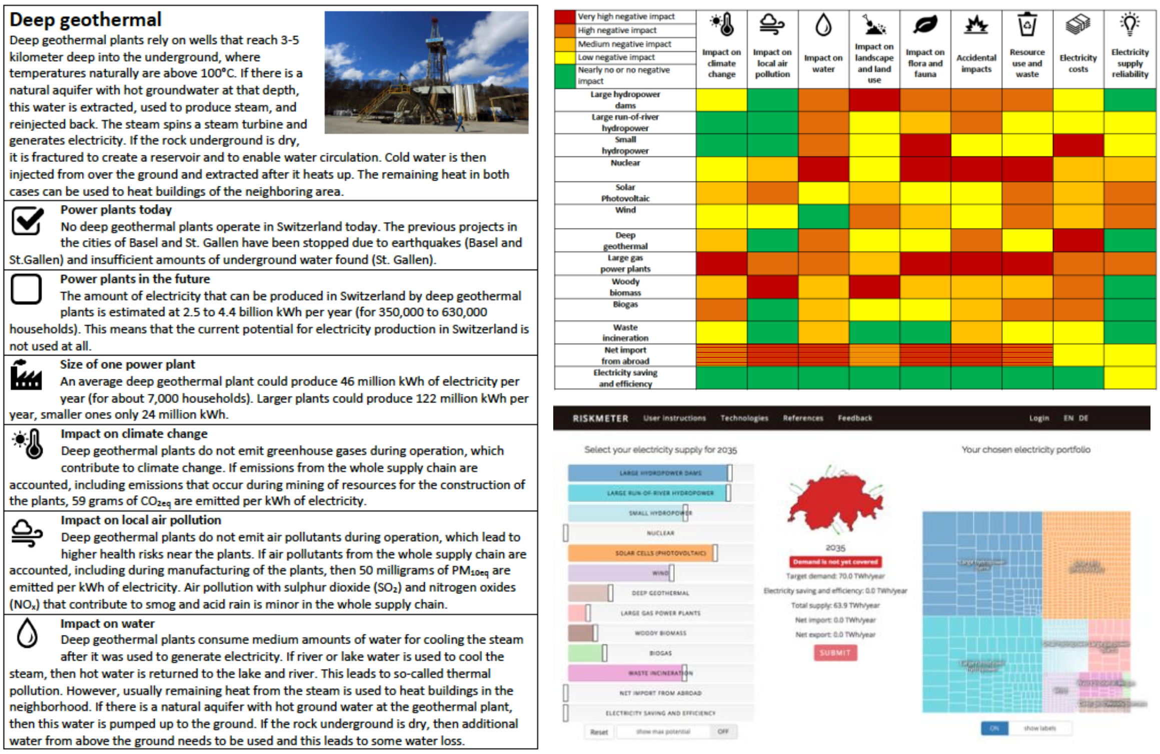

Figure 2: Snapshots of technology factsheets (left and top right) and Riskmeter (bottom left).

In the workshops, we used an interactive web-tool Riskmeter (University of Geneva, 2019; Figure 2) that we developed to build a Swiss electricity mix in 2035 under technology and energy resource constraints. The Riskmeter required the manipulation of electricity produced by each technology in TWh/year to meet the Swiss electricity demand of 70 TWh/year in 2035. With the exception of nuclear, the technologies that are already built today and will last to 2035 were set as the minimum, and the Riskmeter users could not exclude them from their mix. In the case of nuclear, the minimum was set to zero because the Swiss Energy Strategy 2050 foresees stepwise nuclear phaseout in Switzerland to 2035. The maximum potential of each technology due to resource or technical constraints was also set and could not be exceeded by the Riskmeter users.

The informed citizen panel involved 46 participants that came from the German-speaking part of Switzerland. 73% lived in the canton of Zurich and 48% lived in a medium or large city. The age of our participants ranged from 18 to 77 years. The sample was a little older (42.1±16.6 years) than the general Swiss population (41.4 years). 50 % were female, similarly to the Swiss gender ratio of 50.9%. The sample was also more educated than the Swiss average: 66.7% had graduated from high school and 40% had completed at least a bachelor's degree at a university (11.6% and 16.9% in Switzerland, respectively). Most importantly, our informed citizen panel was recruited not to be only as diverse as possible in terms of demographics, but also to have different in their initial technology preferences before receiving the factsheets. In this way, the largest learning effect could be ensured in the group discussion because each participant would be exposed to diverse views of others.

3. RESULTS

3.1 Preferences for electricity generation technologies and the electricity mix 2035

Figure 3 shows the evolution of technology preferences that were elicited from our participants initially (i.e. before receiving the factsheets), after reading factsheets and having a group discussion in the workshops, and in the longer term four weeks after the workshops. The initial, informed, and longer-term preferences indicated a strong preference of the participants for both solar cells and electricity savings and efficiency. For solar cells, the technology ratings decreased significantly after participants read the factsheets and discussed them, but four weeks after the workshop the preferences returned closer to the initial values. For electricity savings and efficiency, the initial preferences increased even more after the factsheets and group discussion. Similar to solar cells, the factsheets had a (positive) short-term effect only because the preferences dropped again closer to initial values four weeks after the workshops.

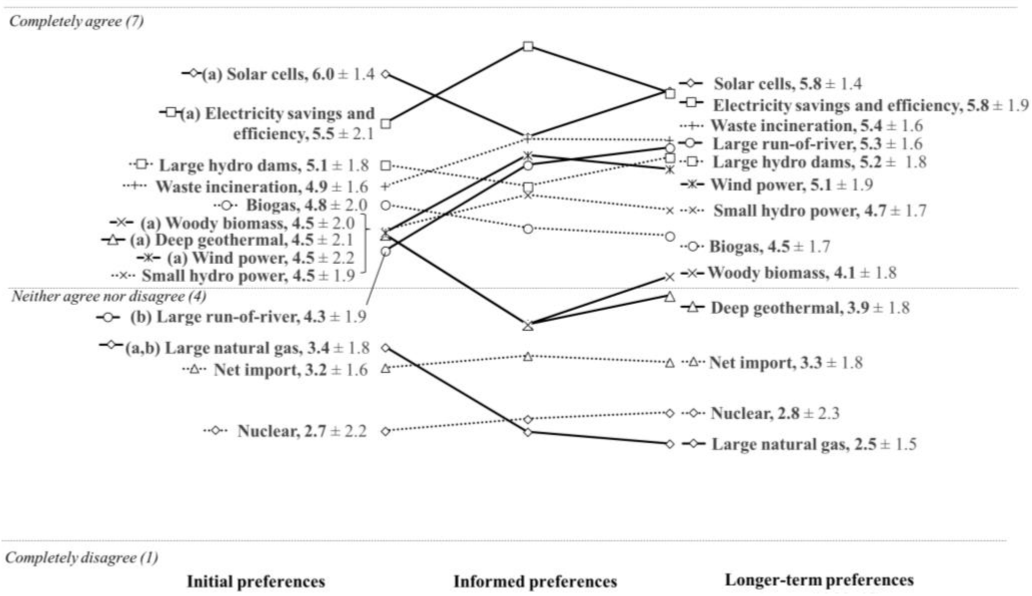

Figure 3: Measured technology preferences in terms of respondents' view of expanding specific types of electricity generation in Switzerland to 2035 (7-point Likert scale, 1=completely disagree to 7=completely agree). Statistically significant differences (p<0.05) are: (a) between initial and informed preferences, and (b) between initial and longer-term preferences. This figure was reproduced from Volken et al. (2018).

Figure 3 also shows that the participants expressed strong support for large hydropower dams because dams are a familiar and trusted technology in Switzerland. These preferences remained unaffected by the information provided. The initial preferences for large run-of-river hydropower showed that people were rather cautious about it, but after the factsheets and group discussion the preferences increased and neared those for large hydropower dams. In fact, there was a statistically significant effect in the longer run too between initial and longer-term preferences, as the increased preferences for run-of-river hydropower stayed four weeks after the workshop. Large run-of-river hydropower, although prevalent in Switzerland, tends to receive less attention in the media than the highly visible large dams or often-debated small hydropower. Our participants therefore may not have been familiar with large run-of-river hydropower at the start, but during the process they learnt about its characteristics and impacts and thus revised their preferences. The participants' preferences for small hydropower remained stable in all assessments and the technology was on average judged just above the midline of "neither agree or disagree".

Initially, our participants also on average supported the expansion of all other decentralized, mostly renewable electricity technologies. For waste incineration, biogas, and wind power the preferences remained comparatively high after the factsheets and group discussions and in the longer run with no statistically significant changes between surveys (except for wind). The preferences for wind power increased after the information, which is consistent with observations from other studies after inducing trade-off thinking (Trutnevyte et al., 2011). In the cases of woody biomass, the process of reading factsheets and discussing in groups led to a statistically significant decrease in preferences. The preferences on average dropped below the middle point of "neither agree nor disagree". Although in the longer run the preferences returned close to the initial preferences, more information seems to have led to declined support for woody biomass.

Across all three points of measurement, technology preferences for large natural gas and nuclear plants as well as for net electricity import (counting on annual basis) were on average below the midline of "neither agree nor disagree." This finding indicates rather negative attitudes of our panel toward these technologies. As we created the panel to have as diverse initial technology preferences as possible, there were also nuclear proponents participating. Factsheets and group discussions did not affect the panel's preferences for nuclear and net import because there were no statistically significant differences between the surveys in Figure 3. But there was a further statistically significant decrease in preferences for natural gas plants. All these technologies are typically viewed negatively in the public opinion surveys in Switzerland (Visschers and Siegrist, 2014). But additional information diminished the preferences for the only fossil fuel option even more. However, it must be noted that Switzerland already now has negligible share of fossil fuels in electricity generation, even if new gas plants were discussed as part of the Swiss Energy Strategy 2050.

3.2 The case of EGS

Figure 3 shows that EGS had a comparatively high initial preference that was similar to the other decentralized renewable electricity technologies: 4.5±2.1 on the 7-point Likert scale (1=completely disagree to 7=completely agree). The process of reading factsheets and discussing in groups led to a statistically significant decrease in preferences that on average even dropped below the midline of "neither agree nor disagree". Although in the longer run, the preferences returned closer to the initial preferences, more information seems to have led to declined support for EGS. As compared with the other technologies, this finding about EGS has important implications. As EGS is a new technology, the participants did not seem to be well familiar with it and might have had misperceptions. In contrast to better known technologies, like nuclear plants or solar cells that had limited response to new information, the panel's participants were receptive to the new information in the factsheets and the Riskmeter about EGS and revised their preference accordingly. That means that any views that are elicited in conventional surveys shall not be assumed as stable – the public opinion about EGS is not yet formed and will likely change as more information appears in the public discussions and media.

Figure 4 shows which environmental, health, or economic impacts were rated as the most important by the participants for making their judgement about EGS. The measurements were conducted before the factsheets (initially), after reading the factsheets and discussing in a group, and four weeks after the workshops. Overall, it can be seen that landscape and land use, accident impacts (including induced seismicity (Knoblauch et al., 2019)), and to some extent climate impacts and electricity supply reliability have been rates as the most important, positive or negative impacts. We can see that with more information, the importance of landscape and land use, climate change and electricity supply reliability decreased, whereas the importance of accident impacts, electricity costs, or local air pollution (in the whole life cycle) increased. These changes also stayed in the longer run, four weeks after the workshops. We argue that most of these changes between uninformed and informed impact ratings reflect the reactions to our factsheets and group discussions. Although some changes could have occurred because the participants initially interpreted the impacts differently from the definitions in our factsheets, multiple changes in impact ratings are still consistent with the changes in technology and portfolio preferences for all technologies (Volken et al., 2018).

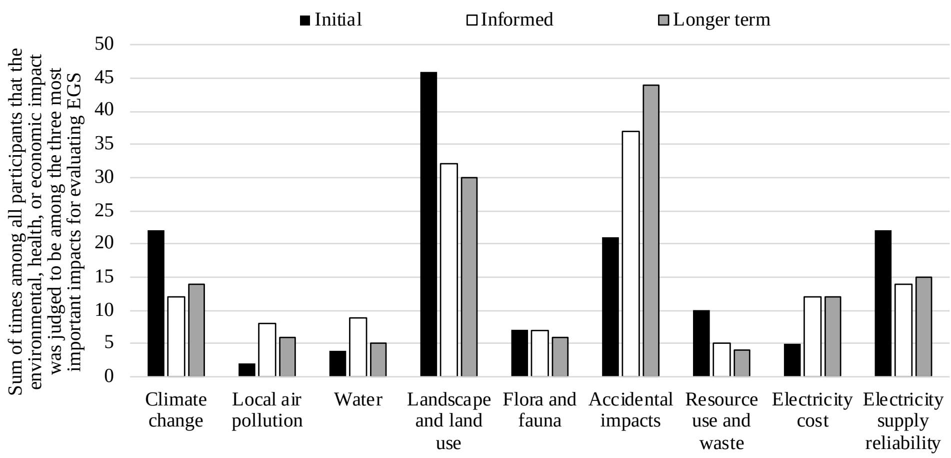

Figure 4: Ratings that show which environmental, health, or economic impacts were rated as the most important by the participants for making their judgement about EGS. Each participant could choose one to three impact categories per technology; the responses were then normalized to three choices per participant and rounded to zero decimals. Complete results are available at (Volken et al., 2018).

3. CONCLUSIONS AND IMPLICATIONS

Our informed citizen panel in the German-speaking part of Switzerland demonstrated strong support for low-carbon electricity sector, especially relying on hydropower, solar cells, electricity savings and efficiency improvements, and to a lesser extent on a diverse mix of other renewable sources. The alternatives of new natural gas power plants or significant shares of nuclear power were not supported by our panel. In fact, we observed a strong backing by our panel for building new plants locally in Switzerland to minimize the annual net electricity import into the country. The EGS preferences had not been stable and were mostly located around the midline of "neither agree nor disagree".

In terms of EGS, the preferences of the informed citizens differed from their initial preferences, i.e. the preferences that would be elicited in a conventional survey. This is an important finding because it shows that, as a new technology, EGS is not yet known to the Swiss population and it may well be surrounded by misperceptions. Therefore, a stable opinion on EGS in Switzerland does not yet exist. The opinion will likely evolve as the public becomes more familiar with pros and cons of EGS after the wider public discussions and media coverage. Even if it is not possible to foresee whether the opinion will eventually be more positive or negative than today as it will depend on these wider discussions, the opinion is still likely to change. For EGS project planners and public authorities, it is thus key to know that any results from opinion surveys on EGS today should not be projected to the future and assumed to represent the future opinions too.

Some EGS experts and planners have argued that, if the broad public would be aware of the actual impacts of EGS and especially their comparison with the other electricity generation technologies, such as solar cells or nuclear power, the public would be likely more willing to accept EGS. Our study shows that more information on EGS does not necessarily lead to increased preference for EGS even if induced seismicity or other EGS impacts are directly compared with the nuclear accident risk, large dam failures, and so on. Enabling such cross-technology comparison and trade-off thinking, in fact, may even lead to lower preference for EGS, especially when EGS need to compete in the whole electricity mix with other technologies that are very much liked in Switzerland, like solar cells or hydropower. Nonetheless, as shown by Volken et al. (2018) in detail, a decreased preference for EGS in Figure 3 does not mean that the informed citizen panel has envisioned the Swiss electricity mix in 2035 without EGS. In fact, when the panel had to create realistic electricity mixes, they still on average included about 1% of electricity supply from EGS.

REFERENCES

Bertsch, V., Hall, M., Weinhardt, C. and Fichtner, W., 2016. Public acceptance and preferences related to renewable energy and grid expansion policy: Empirical insights for Germany. *Energy*, **114**: 465-477.

Fleishman, L.A., De Bruin, W.B. and Morgan, M.G., 2010. Informed public preferences for electricity portfolios with CCS and other low-carbon technologies. *Risk Analysis*, **30**(9): 1399-1410.

Knoblauch, T.A.K., Trutnevyte, E. and Stauffacher, M., 2019. Siting deep geothermal energy: Acceptance of various risk and benefit scenarios in a Swiss-German cross-national study. *Energy Policy*, **128**: 807-816.

Morgan, G.M., Fischhoff, B., Bostrom, A. and Atman, C.J., 2002. Risk Communication: A Mental Models Approach. Cambridge University Press, Cambridge.

Pidgeon, N., Lorenzoni, I. and Poortinga, W., 2008. Climate change or nuclear power—No thanks! A quantitative study of public perceptions and risk framing in Britain. *Global Environmental Change*, **18**(1): 69-85.

Trutnevyte, E., Stauffacher, M. and Scholz, R.W., 2011. Supporting energy initiatives in small communities by linking visions with energy scenarios and multi-criteria assessment. *Energy Policy*, **39**(12): 7884-7895.

Trutnevyte, E., Volken, S. and Xexakis, G., 2019. Factsheets of electricity generation technologies in Switzerland (EN). *Zenodo*, http://doi.org/10.5281/zenodo.2556569.

University of Geneva, 2019. Riskmeter. www.riskmeter.ch.

Visschers, V.H.M. and Siegrist, M., 2014. Find the differences and the similarities: Relating perceived benefits, perceived costs and protected values to acceptance of five energy technologies. *Journal of Environmental Psychology*, **40**: 117-130.

Volken, S., Wong-Parodi, G. and Trutnevyte, E., 2019. Laypeople's beliefs and acceptance of risks of electricity generation technologies. *Journal of Risk Research*, **22**(4): 432-447.

Volken, S., Xexakis, G. and Trutnevyte, E., 2018. Perspectives of informed citizen panel on low-carbon electricity portfolios in Switzerland and the empirical evaluation of informational material. *Environmental Science & Technology*, **52**(20): 11478-11489.

Wong-Parodi, G., Krishnamurti, T., Davis, A., Schwartz, D. and Fischhoff, B., 2016. A decision science approach for integrating social science in climate and energy solutions. *Nature Climate Change*, **6**(6): 563-569.