Bad News Is Bad News: Information Effects and Citizens' Socio-Political Acceptance of New Technologies of Electricity Transmission

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Accepted version published in *Land Use Policy 81 (2019) 531–545*

Abstract

This contribution focuses on citizens' attitudes towards new technologies in electricity transmission and asks how information provision affects citizens' attitudes towards different technological solutions. It is thereby assumed that the relevance of information is contingent on whether a technology is new or established, as well as on how the information is framed. Electricity transmission is linked to the transition of energy systems from fossil and nuclear to renewable sources. The analyses therefore contribute to the ongoing debate on how to successfully implement new technical solutions in renewable energy policy. Methodologically, the paper uses novel data from a large-scale population survey conducted in Switzerland and tests information effects based on an experimental split ballot design. The results reveal that whereas public opinion on conventional technologies is rather stable, citizens react strongly to information on new technical solutions. This is particularly the case if the information emphasizes negative aspects and uncertainties of the new technologies. Moreover, such negative information can barely be compensated by simultaneous positive information.

Keywords: Social acceptance, electricity transmission, information effects, framing, experimental survey

Introduction

In the wake of the envisaged transition of energy systems from fossil and nuclear to renewable energy sources, many countries are upgrading and developing their electricity transmission networks (Devine-Wright & Batel, 2013; ENTSO-E, 2014). On the one hand, this is a trend towards distributed generation (e.g., Ackermann, Andersson, & Söder, 2001; Dondi, Bayoumi, Haederli, Julian, & Suter, 2002) that may be related to a lower dependency on electricity transmission. However, on the other hand, large-scale electricity production from renewable energy sources—e.g., large-scale hydropower plants, wind parks (offshore), or solar parks—is typically situated in more remote areas. Thus, the development of such energy production plants may also involve the construction of new or more efficient transmission lines (Devine-Wright, 2005; Soini, Pouta, Salmiovirta, Uusitalo, & Kivinen, 2011; Wüstenhagen, Wolsink, & Bürer, 2007). Real life experience and research and has shown that citizens tend to be skeptical about such lines (Soini et al., 2011). High voltage lines share many similarities with renewable energy generation infrastructure, which tends to trigger opposition, even when people generally approve of the overarching goal (e.g., the promotion of renewables) or the related technology (e.g., wind energy) (Devine-Wright, 2011; Soini et al., 2011; Wüstenhagen et al., 2007). Recently, an increasing number of studies have focused on the "social side" (Batel, Devine-Wright, & Tangeland, 2013) of renewable energy technologies (RET) implementation. Thus, a lack of *social acceptance* is "one factor that can potentially be a powerful barrier to the achievement of renewable energy targets" (Wüstenhagen et al., 2007, p. 2683).

The present study examines *how information provision affects public acceptance of new technologies of electricity transmission.* The new technology under consideration is the conversion of existent power lines to so-called *hybrid power lines* that combine alternating current (AC) with direct current (DC) at the same tower. Although these hybrid lines can substantially increase transmission capacity, this new technology involves some challenges, in particular, the

ground level electrical field and audible noise are likely to increase (Hedtke, Pfeiffer, Gaillard, & Franck, 2016). Thus, questions related to social acceptance are not only relevant with regards to transmission lines in general, but also with respect to how the public may react to the advantages and disadvantages of the new technology.

The motivation of the present study is twofold. First, although the literature on the public's acceptance of renewable energy policy supports the view that information provision affects the social acceptance of renewable energy and related technologies, the mechanisms driving information effects are theoretically underdeveloped. Moreover, it is not clear empirically whether and under which conditions information increases (e.g., Cohen, Moeltner, Reichl, & Schmidthaler, 2016) or decreases (e.g., Reiner et al., 2006) social acceptance.[1] The present study theoretically and empirically uses the framing of information to better understand the mechanisms and contingencies driving information effects. In this vein, it also relies on the assumption of public opinion research that citizens' evaluation of new, and thus unknown, issues (and technologies) is strongly dependent on the specific information they receive. Second, previous studies focusing on electricity transmission imply that international heterogeneity exists with regards to the social acceptance of electricity transmission (Aas, Devine-Wright, Tangeland, Batel, & Ruud, 2014; Batel et al., 2013; Cohen et al., 2016; Devine-Wright, 2013; Knudsen et al., 2015). Thus, the present study's focus on Switzerland adds a new case and new contextual aspects to the debate. Due to the strong reliance on direct democracy in Switzerland, the role of citizens and their perspectives on electricity transmission may have more impact on the decision-making processes regarding electricity transmission than the role played by citizens who live in countries that have purely representative political systems. Moreover, given

[1] A similar conclusion applies to the research focusing on carbon capture & storage (CSS) infrastructure (de Best-Waldhober et al., 2009; Itaoka et al., 2009; Palmgren & Keith, 2004).

Switzerland's small size and high population density, questions concerning infrastructure siting are particularly sensitive and typically trigger high levels of opposition.

Whereas opposition to energy-related infrastructure most often has been analyzed at the local level and, thus, from the perspective of community acceptance, the present study focuses on the socio-political dimension (Wüstenhagen et al., 2007) that denotes how policies and technologies are perceived by political stakeholders and the broad public (Dermont, Ingold, Kammermann, & Stadelmann-Steffen, 2017, p. 360). This perspective is in accordance with the aim to analyze a *new* technology— hybrid power lines—that has not been constructed yet in a real-world scenario. It can be argued that if the public already is skeptical about this new technology at this most general level, it probably will be difficult to find market acceptance (e.g., grid operators willing to use the technology) and particularly community acceptance (e.g., non-opposition during local siting processes). In this regard, an important difference between energy transmission and RET infrastructure, such as wind parks, needs to be mentioned. Whereas renewable energies and related technologies have been shown to be popular with citizens (i.e., contributing to a high socio-political acceptance, Wüstenhagen et al., 2007, p. 2685), high voltage lines do not have a similar general positive connotation but rather are among the least popular energy item (Soini et al., 2011). This might be due to the fact that electricity transmission and related infrastructures do not provide an obvious local economic benefit (Knudsen et al., 2015), nor are they directly and obviously linked to renewable energies (Lienert, Sütterlin, & Siegrist, 2017).

Empirically, I use a novel large-scale population survey from Switzerland that includes a module on high voltage lines, and experimental survey elements to test for information effects.

The remainder of the present study is structured as follows. Next, previous research on the social acceptance of renewable energy policy and public opinion research are presented, and hypotheses are developed on the role of information on opinion formation. The next section

discusses the data and methods, and then a following section provides the empirical results. The study closes with a summary of the most important results and some conclusions.

Theoretical background

Research on the siting of energy-related infrastructure has emphasized repeatedly that the reasons and mechanisms driving the resistance towards these projects are multiple and complex, and clearly go beyond the famous NIMBY syndrome (Wolsink, 2000). In particular, procedural aspects such as citizens' involvement, information, or perceptions of fairness have been identified as influencing whether the an implementation process is successful (Aas et al., 2014; Batel & Devine-Wright, 2015; Bidwell, 2016; Cohen et al., 2016; Dermont et al., 2017, p. 361; Gross, 2007; Jobert, Laborgne, & Mimler, 2007; Knudsen et al., 2015; Soini et al., 2011). However, we still lack systematic insights on the mechanisms that drive such process-related factors (Knudsen et al., 2015). Whereas most of these studies have focused on concrete siting projects, and thus, the dimension of community acceptance (Wüstenhagen et al., 2007), the present study assumes that the role of information also is important at the more general socio-political level of acceptance. This assumption should be particularly true with respect to citizens' attitudes towards new technologies for which an *ex-ante* level of knowledge and information is limited.[2]

Initially, this assumption is supported by previous research on the role of information and public attitudes towards energy-related technologies and infrastructure. For example, with respect to carbon capture and storage (CCS), Fleishman et al. (2010, p. 1400) have found that people's opinions became more stable and more consistent with their values as they receive more information and become better informed. Moreover, the provision of information not only

[2] Throughout the present study, I use the terms *public acceptance, citizens' attitudes,* and *public opinion* synonymously to describe actors' reactions. I am interested in citizens' socio-political acceptance, and thereby its *attitudinal* component (see e.g., Dermont et al. 2017; Batel et al. 2013).

assures that citizens are informed about the "hard facts," but also is important in terms of responsiveness (Ciupuliga & Cuppen, 2013). Accordingly, a series of studies have investigated citizens' attitudes towards environmental and/or energy issues contingent on previous information provision (de Best-Waldhober, Daamen, & Faaij, 2009; Itaoka, Okuda, Saito, & Akai, 2009; Knippenberg & Daamen, 1996; Palmgren & Keith, 2004; Reiner et al., 2006). However, these analyses do not discuss theoretically why and how information matters to public opinion. Moreover, the information effects found seem "to lack a general direction" (de Best-Waldhober et al., 2009, p. 324). Of course, these studies do not focus on high voltage lines but mostly concern infrastructure related to CCS. With respect to these studies, although we cannot conclude necessarily that information provision affects public opinion on these various "objects" in the same way, we can conclude the following: first, that information has the potential to influence public opinion on infrastructure, and second, that we need to carefully consider the different theoretical mechanisms related to why and how these information effects can be observed (or not).

Public opinion research also maintains that information provision has an effect on what people think about a technology. Thus, opinions are endogenous to the political process, i.e., they are created, altered, and transformed during the political process (Hansen, 2007, p. 379). Most prominently, Converse (1964, p. 241) has argued that public opinions are "extremely labile for individuals over time" and that citizens do not have stable and meaningful attitudes even on issues that already have been intensively discussed among the elites (ibid., p. 245). This ambiguity opens the door to information effects, i.e., mass opinion is also the result of what people hear or read about a political issue (Druckman, 2004; Zaller, 1992).

The main assumption of the present study is that the policy information citizens receive has the potential to affect what they think about an issue, i.e., a technology. However, to understand the mechanisms driving information effects and to solve the puzzle of the inconsistent

results of previous studies on infrastructure and technologies, it is important, theoretically and empirically, to consider that the impact of information on citizens' opinions is contingent on various factors (Hopmann, Vliegenthart, De Vreese, & Albæk, 2010; Wood & Vedlitz, 2007; e.g., Zaller, 1992). The following section and the empirical analyses focus on two such contingencies. First, they examine which *type of technology* citizens' are most reactive to, in particular to what extent information effects vary depending on the novelty of a technology. The second contingency concerns *the information frame*, i.e., whether information effects are contingent on whether the information provides the positive or negative aspects of a technology.

When information matters: The case of new technologies

Most studies on the acceptance of RET and its related infrastructure have found that citizens' tend to have positive general attitudes regarding renewable energy projects (socio-political acceptance), but fiercely oppose concrete implementations of RET at the local level, e.g., the construction of a new windfarm or a new transmission line close to where they live (community acceptance) (Dermont et al., 2017; Devine-Wright & Batel, 2013; Wüstenhagen et al., 2007). Conceptually, this gap has often been explained by the famous Not-In-My-Backyard (NIMBY) syndrome, i.e., a rejection of local projects due to egoistic behavior, even though the technology in general is accepted. More recently, however, it has been emphasized that local opposition can be the result of legitimate concerns about the process or the proposed project in the planned area (Bell, Gray, & Haggett, 2005; Bell, Gray, Haggett, & Swaffield, 2013; Warren, Lumsden, O'Dowd, & Birnie, 2005; Wolsink, 2000). Empirically, and relatedly, several studies have shown that (local) experience with a technology decreases rather than increases opposition (e.g., Braunholtz & McWhannell, 2003; Firestone, Kempton, Lilley, & Samoteskul, 2012;

Wolsink, 2007).[3] For example, with respect to high voltage lines, Soini et al. (2011, p. 303) have shown that individuals who live in an area with high voltage lines exhibit more positive perceptions towards these lines than respondents who do not have a real-life experience with them. Thus, an important gap seems to exist between people's negative perceptions about new local projects and their actual experiences. Moreover, if opposition exists, it often is the result of skepticism regarding the technology as such, which also may be triggered during the decision-making process, i.e., if the debate alters risk perceptions (Dermont et al., 2017; Gross, 2007; Wolsink, 2000; see also Ricci, Bellaby, & Flynn, 2008; Warren et al., 2005). Risk perceptions seem to be of particular importance with respect to new technologies (O'Garra, Mourato, & Pearson, 2005). In other words, technical solutions that are largely unknown to the public generally tend to arouse scepticism. Even if scientific assements are clearly positive, public opinion perceives new technologies as risky and unsecure (Schulte, Hart, & Van der Vorst, 2004, p. 678).

These findings can be supported theoretically by public opinion research. As previously mentioned, prior knowledge and attitudes regarding an issue affect information processing. Most importantly, these predispositions influence what and how information is integrated during opinion formation (Wood & Vedlitz, 2007; Zaller, 1992). Citizens tend to accommodate information that accords with their prior beliefs, and dismiss evidence that challenges these beliefs. Thus, "[o]nce people have an initial assessment of a problem […] they will use it to anchor subsequent judgments and thus inadequately revise their beliefs to accommodate new information" (Mercer, 2005, p. 8; see also Slothuus & de Vreese, 2010; Taber & Lodge, 2006).

[3] Although only a few studies based on longitudinal (pre-post) data have tested the changes in attitudes towards RET infrastructure after real-life experiences, several studies have compared different groups of citizens—people living close to an infrastructure with persons not living near to such infrastructure—lending support to the argument that real-world experiences are conducive to the public acceptance of RET infrastructure (Ek, 2005; Warren et al., 2005).

The same mechanisms can be expected to be relevant to information effects regarding attitudes towards new and conventional technology. Conventional technical solutions are "issues" for which predispositions exist based on previous experiences, discussions, and processes. Applying the arguments from information processing research, we can conclude that more or new information will not have any large impact on citizens' attitudes regarding these conventional technologies, since they already have developed specific attitudes at an earlier time. For example, if they receive information that accords with their prior experiences and beliefs, they will feel confirmed in these opinions, and will not consider, to any great extent, the information that contradicts their prior attitudes.

However, the situation is somewhat different with respect to new technologies. "New" issues are characterized by the "absence of general agreement about how to construe them" (Chong & Druckman, 2007, p. 107) or a lack of issue-specific predispositions (Zaller, 1992). Thus, when faced with new technical solutions, citizens cannot draw on prior experiences and beliefs to help them with the evaluation process. As a result, the probability increases that information about these new technologoical solutions actually contributes to opinion formation. Moreover, in this context, chances are high that citizens will receive *new* information, which has the potential to change individual opinions, most importantly when the information contains scientific evidence related to a technical issue (Wood & Vedlitz, 2007, p. 554).

From the empirical and theoretical insights of the two strands of literature just discussed, I conclude that information effects will be stronger with respect to new technologies, compared to established technical solutions, which tend to build on citizens' experiences and stable predispositions, and thus reduce the likelihood of opinion change. In contrast, prior experiences and stable predispositions do not apply to new technologies, and citizens also are more likely to receive novel information that will impact their opinions. I therefore hypothesize the following:

H1: Information effects are stronger for the new technologies of electricity transmission than for the established technologies.

What type of information matters? Negative vs. positive information

Based on (issue) framing theory (Chong & Druckman, 2007), it can be expected that information can convey quite different messages regarding an issue. From this perspective, issue frames "focus on qualitatively different yet potentially relevant considerations" (Druckman, 2004, p. 672) of an issue and thereby refer to information that can mobilize citizens to think about specific issues along particular lines, i.e., by highlighting the specific features of a policy, such as its positive or negative effects (Chong & Druckman, 2007, p. 106; Jacoby, 2000, p. 751; Shah, Watts, Domke, & Fan, 2002, p. 343). Thus, *framing* is considered to be a "process by which people develop a particular conceptualization of an issue or reorient their thinking about an issue" (Chong & Druckman, 2007, p. 104). The framing of information in different ways influences people's attitudes towards an issue by changing underlying considerations and their salience used to evaluate the issue (Berelson, Lazarsfeld, & McPhee, 1986; Chong & Druckman, 2007; Nelson, Oxley, & Clawson, 1997).

Especially in the context of new technologies towards which people do not have strong predispositions, we can expect that a positive or negative framing of information will influence what people think about an issue at stake. Thus, I hypothesize the following:

H2: Negatively framed information will lead to more negative attitudes towards new technology, whereas positively framed information will lead to more positive opinions towards new technology.

However, based on prospect theory (Kahneman & Tversky, 1979), a contrasting expectation can be formulated. Similar to framing theory, this approach theorizes that individual decisions depend on the situational context and the framing of an object (McDermott, 2004, p. 290). Whereas traditional rational choice approaches argue that the framing of information does not influence citizens' decisions and choices, Kahneman and Tversky (1979), in their famous contribution, show that the framing of information actually does influence decision-making (Mercer, 2005). However, in contrast to framing theory, these authors emphasize that whether we interpret choices as gains or losses influences our attitudes towards risky options, and also how we process information. More precisely, "people hate to lose even more than they love to win and […] this will systematically bias their attitudes towards risks" (Mercer, 2005, p. 3). In other words, the negative aspects of an issue are accorded more weight than the positive aspects of an issue (McDermott, 2004, p. 291). Relatedly, individuals tend to think that moderate to high risks are "no big deal," but they also may interpret small risks as big threats (ibid.).

The present study is not about risk attitudes; rather, it is concerned with the hypothesis that the uncertainties and potential negative aspects of an issue can affect individuals in particular ways that can impact the acceptance of the new technologies of electricity transmission. If a new technology involves uncertainty and potential negative effects, these potential "losses" may influence citizens' attitudes to a greater extent than potential positive effects, which often may be long-term gains. These patterns will be most pronounced if the information that people receive about a new technology emphasizes the potential risks rather than the benefits. Thus, I formulate the following hypothesis:

H3: Negative information, compared to positive information, more strongly influences citizens' attitudes towards new technologies of electricity transmission.

The distinction between positive and negative information does not refer to the more normative question of whether the information is correct or appropriate. In fact, opposition to

a particular project may arise for good reasons, e.g., since the project is not well developed or suitable in a certain context (Aitken, 2010). In other words, "negative information" pointing to the risks and weaknesses of a project may actually produce the desired outcome (Dermont et al., 2017; Devine-Wright & Batel, 2013). Thus, the positive and negative information that is provided to the population during an implementation process is not necessarily indicative of the quality of the process. For example, a situation in which a lot of positive information is distributed top-down and very little negative information is available from more bottom-up sources may be linked to hierarchical processes that have been shown to be problematic from a social acceptance point of view (Batel et al., 2013).

Data and Method

The data set used by this present study was collected in Switzerland. With respect to Switzerland, the *Strategy Electricity Grid* (Federal Council, 2013) emphasizes the relevance of the transmission grid (high voltage) in the context of renewable energy production. On the one hand, this document mentions the development of the transmission grid within the country and its connection to the European grid and, for example, to new offshore wind parks in the north. Moreover, this report is concerned with the increased importance of the grid's flexibility, and the interplay between the transmission and distribution grids, which require development (Lienert et al., 2017).

The trilingual survey[4] on future energy provision in Switzerland collected 8'287 interviews from a representative sample provided by the Federal Office of Statistics; respondents where invited by postal mail to participate in the online survey.[5] After three invitations, the

[4] The survey was conducted in German, French, and Italian—the three main national languages of Switzerland; 65.4% filled out the survey in German, 26.0% in French, and 8.6% in Italian. Romansh individuals likely used the German version to answer the survey.

[5] The data collection process was conducted by LINK Institute in Lucerne. The sample was provided by the Federal Office of Statistics out of the "Stichprobenrahmen für Personen- und Haushaltserhebungen" (SRPH).

response rate was at 41.7%. 1’129 respondents (randomly drawn from the overall sample) received a module on the acceptance of (hybrid) high voltage lines. The data from these respondents are the empirical basis for the results that follow in the present study.

The demographic and structural composition of the sample corresponds quite closely to the Swiss resident population (See Table A.1), which is particularly true with respect to gender, civic status, and education. Foreigners living in Switzerland as well as citizens older than 75 years had a lower response rate, which likely was the result of the exclusive use of an online survey. In terms of political orientation, the collected sample was very similar to the composition of Swiss voters according to the Swiss Election Study 2015 (Lutz, 2016), the exceptions were that support for the larger parties was comparatively higher, and the ideological position of the respondents on the left-right scale was somewhat less polarized.

The dependent variables measure individuals’ attitudes towards high voltage lines. To increase grid capacity, two technological possibilities take center stage. On the one hand, a new transmission line parallel to an existing line could be constructed (i.e., using the conventional technology to increase grid capacity). On the other hand, new technological developments, i.e., hybrid power lines, could help to increase the transmission capacity of an existing line by combining AC with DC power on the same tower. However, the new technology of hybrid power lines involves some challenges—in particular, the ground level electrical field and audible noise levels are likely to increase (Hedtke et al., 2016). A third technical solution is the use of underground cables, for which only limited information is available in the data. Thus, in the present study, this alternative has been used as a control case, for several reasons, to test the robustness of the main results. First, whereas this type of electricity transmission has been discussed most prominently as an alternative to overhead lines (Lienert, Sütterlin, & Siegrist, 2018; Tempesta, Vecchiato, & Girardi, 2014), and is being used regularly at the level of the (sub-)distribution grid, little operational and construction experience exists with respect to the use of underground

cables for high voltage transmission (above 220kV) (Swissgrid, 2017). This lack of experience makes underground cables also a "new" technology at the high voltage level. Second, this technology can be expected to be more popular than hybrid lines, not only in the sense that politicians[6] and citizens have shown support for this solution, but also because the public seems to be able to understand it better than hybrid line technology. Third, however, this new technology also has some disadvantages. In particular, engineers have argued that underground cables are much more expensive, make necessary quite heavy interventions into the land/soil, and are more difficult to use with respect to maintenance and troubleshooting (Swissgrid, 2017). Thus, underground cables can be considered to be a new technology that involves some challenges similar to hybrid lines, but they also may be more strongly (and more positively) predisposed given that underground cables regularly are used at a lower voltage (e.g., in a distribution grid).

To capture citizens' attitudes towards the variants of overhead lines, I used three survey items.[7] First, to measure *absolute attitude* levels, I relied on the following questions:

> ***Attitudes towards a new line:*** *"Would you approve the construction of a new high voltage line close to where you live?"*
>
> ***Attitudes towards a hybrid line:*** *"New technological developments can be used to convert existing high voltage lines to increase transmission capacity by about 50 percent, meaning that conversion could be an alternative to the construction of a new line.*
>
> *Independently of whether there is a high voltage line close to where you live, would you approve the conversion of a high voltage line into a hybrid line close to where you live?"*

[6] The Grand Coalition in Germany, for instance, decided in 2015 to prioritize the construction of new high voltage lines as underground cables (https://www.tagesschau.de/inland/stromtrassen-111.html). In Switzerland, the federal government in its *Electricity Grid Strategy* stated that both underground and overhead solutions must be considered when constructing new lines ("Botschaft zum Bundesgesetz über den Um- und Ausbau der Stromnetze (Änderung des Elektrizitätsgesetzes und des Stromversorgungsnetzes)", 16.035.

[7] Whereas the three items used in the following analyses enable to capture of citizens' attitudes towards technologies of electricity transmission from different angles, in particular, based on single-item questions (what I call *absolute attitudes*) and a choice question (i.e., *relative attitudes*), there is no possibility of distinguishing between different citizens' reactions, for example, between acceptance and support (Batel et al., 2013).

In both cases, respondents had to indicate whether they would (surely) approve or (surely) disapprove such a project.

However, these responses may reflect rather isolated views that do not take into account a balancing of different solutions (which might be the real-world scenario in the near future). Thus, I used a third question to caputure *relative attitudes*, i.e., when chosing between alternatives:

> ***Relative attitudes****: "Independent of whether you are for or against high voltage lines, would you rather support the construction of a new line or the conversion of an existing line?"*

The response categories were "Surely constructing a new line," "Rather constructing a new line," "Rather converting an existing line," and "Surely converting an existing line."

The crucial independent variables are information treatments that have been provided to respondents in an experimental split ballot approach. More precisely, respondents were randomly assigned to either a control group or treatment group, and the treatment group received some additional information. Two differently (i.e., positively and negatively) framed information treatments were used, which enable the testing of the framing effects discussed in the theoretical section of the present study. First, as an introduction to the questions about the technologies of electricity transmission, half of the respondents received the following treatment:

> ***Treatment 1 (positive)****: "High voltage lines are necessary for electricity transmission from where the electricity is produced to where it is used. However, today's grid capacity will not be able to meet future demands."*

I consider this to be a positive treatment because it basically informs respondents about the need to adopt one or another technical solution, i.e., that the status quo is not a feasible alternative.

Thus, this treatment should positively affect individuals openness to change, i.e., to approving the construction of a new line or the adoption of a new technology.[8]

Before being asked the questions about hybrid power lines, respondents were again split into a treatment and a control group; for the treatment group, I extended the introductory information about hybrid high voltage lines to include the following information that emphasizes some risks and uncertainties related to this new technology:

> ***Treatment 2 (negative):*** *"However, this new generation of high voltage lines may produce more noise and may be felt more strongly when standing directly underneath a line."*

Whereas most previous studies have focused on the visual impact of these infrastructures on the landscape and environment (Devine-Wright & Batel, 2013; Knudsen et al., 2015; Lienert et al., 2017; Tempesta et al., 2014), health-related risks and fears rarely have been investigated. However, the survey data from Switzerland suggests that health-related concerns dominate over the visual and landscape impacts (see Figure A1. in the Appendix), and, thus, may be particularly relevant with respect to the level of public acceptance of the new technology.[9]

Regarding conventional technology, i.e., the construction of a new line, a negative treatment was not used.[10] Thus, unfortunately, I will not be able to systematically analyse the role of a negative information treatment on an established technical solution (see Figure 1).

[8] Of course, an alternative positive treatment could have been used to remind respondents of the link between electricity transmission and renewable energy. However, and as discussed in the introduction of the present study, the association between renewable energy and electricity transmission is not simple, since an increase of renewable energy could both involve more but also less electricity transmission. Moreover, respondents vary concerning their approval of renewable energy. Thus, these various and sometimes contrasting associations make the formulation of a clear information treatment—and, relatedly, of consistent expectations about the treatment effect—challenging.

[9] Tempesta et al.'s (2014) data show a similar result, since a majority of their respondents indicated that the environmental impacts of new technologies are more relevant than the landscape issues related to these technologies.

[10] Unfortunately, such a negative treatment effect was not included in the survey experiment, which originally aimed to capture the volatility in attitudes towards new technology, and so was not an explicit test of the positive and negative information effects for different technological solutions.

--- Fig. 1 about here ---

Further analyses show that the randomization of the treatment was successful, i.e., the treatment and control groups are very similar with regards to standard socio-demographic and economic variables, and also the distribution of attitudinal variables was similar (see online documentation). In principle, this successful randomization enables the evaluation of information effects based on testing the differences between the treatment and control groups (and by using Mann-Whitney-Wilcoxon tests to assess the statistical significance of these differences). However, in the course of the analyses, I estimated a series of regression models to test the robustness of the treatment effects reported below. I estimated logistic models to predict the approval of new and hybrid high voltage lines, respectively. Individuals, who indicated to "surely" or "rather" approve a new and a hybrid line, respectively, were assigned the value of 1, whereas all others were assigned zero.[11] In these models, I considered additional individual characteristics that have been found to be relevant to environmental attitudes in general, and for renewable energy in particular. Most importantly, prior attitudes and prior experience with regards to high voltage lines have been considered. I measured prior attitudes by how disturbing respondents considered high voltage lines in general (on a scale from 1 [Not disturbing] to 4 [Disturbing]). I operationalized prior experience by using a dummy variable by which individuals living close (around 1km) to a high voltage line were assigned the value 1, whereas all others were coded as zero.[12] In addition, I also considered the following variables: gender, ed-

[11] In additional models, I also estimated ordered logistic regressions, which enabled a consideration of the full information from the dependent variables, i.e., accounting for the fact that the response variable is a Likert-scale, i.e., individual (partial) agreement or (partial) disagreement for a statement. However, robustness tests imply that the parallel regression assumption, which is fundamental to ordered logistic models, needs to be rejected with respect to the present data.

[12] I have relied on self-reported closeness to high voltage lines.

ucation, age, left-right political self-placement, whether individuals give priority to the economic use of natural resources or to nature and landscape protection, whether an individual has a technical education or training (and therefore is possibly less skeptical towards new technologies) or children (to account for whether individuals are possibly concerned about future generations). More detailed information on the variables, their operationalization, and summary statistics can be found in Table A.1 in the Appendix.

Empirical results

Initially, high voltage lines cannot build on a general high level of support or positive predispositions. Roughly 51% of respondents to the present study indicate that high voltage lines are (rather) disturbing. Figure 2 illustrates, however, that perceptions of high voltage lines are related to real-world experiences. Among the respondents who do not live close to such a line, a clear majority perceives high voltage lines as disturbing. Conversely, individuals living close to a high voltage line share this negative opinion to a significantly lesser extent. Only a minority (42%) approves the statement that high voltage lines are (rather) disturbing. This finding—together with the previously mentioned fact that respondents care most about the health issues related to high voltage lines, and to a lesser extent about their visual impacts (see Figure A.1 in the Appendix)—implies that the rejection of high voltage lines is not the result of negative real-world experiences, but is rooted in rather abstract fears and ideas. These negative feelings are related most importantly to the fear of negative impacts on humans (and to a lesser extent on the potential negative impacts on the landscape and animals), which for many people do not seem to materialize when living close to a trasmission line. Also worth mentioning is that the share of undecided respondents was extremely low, which supports the assumption that conventional high voltage lines are a highly predisposed issue.

--- Fig. 2 about here ---

Given the rather negative feelings towards power lines, how do citizens evaluate a new technology and how does information impact their attitudes towards electricity transmission? Figure 3 demonstrates that a clear majority—in accordance with the skepticism represented in Figure 2—does not support the construction of a new transmission line. Figure 3 also illustrates that informing respondents about the need to increase grid capacity (T1, positive treatment) leads to a significantly higher approval of a new transmission line. Respondents who were informed that grid capacity needs to be increased are significantly more likely to agree to the construction of a new line close to where they live. The shift, however, mostly concerns the group that "rather supports" a new line, since the proportion of those who "surely" accept a new line remains largely stable. Overall, an information effect regarding the conventional technology of electricity transmission can be observed, but it seems to be quite limited from a substantial point of view. Moreover, even in the context of the positive information treatment, the construction of a new line is approved only by a minority of respondents.

--- Fig. 3 about here ---

Whereas the influence of an information treatment on attitudes towards traditional transmission lines is limited, the influence of information on attitudes about new energy transmission technology is greater. The lower two graphs in Figure 3 show to what extent respondents support the conversion of an existing high voltage line into a hybrid line, and thus the use of a new technology. Thus, the positive treatment (T1) augments the approval of conversion significantly, and also increases the number of those who indicate that they "clearly approve" this new

technology. After being informed about the need to increase grid capacity, a majority of the respondents has a positive response to the new technology.

However, the treatment effect is clearly stronger with respect to the negative information treatment that specifically relates to the new technology (T2). Approval for hybrid lines is high in the control group, i.e., among those respondents who received only basic information about the new technology, and most importantly about its higher transmission capacity. Almost 3 out of 4 respondents indicate that they approve of the conversion of an existing line close to where they live. However, the rate of approval is much smaller for the treatment group who also was informed about the fact that this new generation of high voltage lines could produce more noise and be more strongly perceptible. Only one third of this group approves the conversion of an existing transmission line close to their domicile.

Thus, comparing the results regarding the construction of a new high voltage line, i.e., using conventional technology, and the new technical solution supports Hypothesis 1: Information effects—as tested in the survey context—are stronger for a new technology, regarding which *ex-ante* knowledge is lower, and thus predispositions have not developed. This conclusion is corroborated particularly by the finding that the general positive treatment—which was provided directly to respondents before the questions about conventional power lines—produces a stronger effect on attitudes towards the new hybrid technology.

Moreover, the results concerning hybrid power lines illustrate that, depending on the framing, the information effect can go in both directions. Approval of the new technology increases after positive information, and is reduced when respondents received negative information (which is in accordance with Hypothesis 2). However, the strong reduction in the approval of hybrid lines—when the respondents received the negative treatment—implies that citizens may be particularly reactive to potential negative consequences. This latter conclusion (as hypothesized in Hypothesis 3) is further supported by Figure 4 that provides the combined

treatment effects. This Figure distinguishes four groups based on a combination of the information treatments. A quarter of the sample did not receive an information treatment ("None"); two other groups received either the positive or the negative treatment; and the fourth group was provided with both the positive and negative information treatments ("Both"). This analysis demonstrates that negative information is the crucial trigger for respondents' reported attitudes towards the new technology. Whereas the two groups that did not receive the negative treatment exhibit a majority approval of hybrid lines, the rate of approval clearly decreases for those who received negative information. Most importantly, however, with respect to the individuals who received both negative and positive information, the positive treatment was not able to compensate for the negative information effect (the distributions for the groups "Negative" and "Both" are the only ones that do not vary significantly[13]). This group's attitudes barely differ from the group that exclusively received the negative information. These findings provide empirical support for Hypothesis 3 and prospect theory, i.e., that citizens react more strongly to negative information.

--- Fig. 4 about here ---

Next, the results concerning relative attitudes are presented, i.e., whether citizens prefer the new or conventional technology when they must choose between these two solutions. Figure 5 demonstrates that attitudes towards the new technology are more positive and stable when contrasted with the alternative, i.e., the conventional solution. A clear majority of respondents in all groups indicated that they would "rather" or even "surely" prefer the conversion of an existing line to increase grid capacity, instead of constructing an additional conventional line. Thus, even though skepticism exists with regards to the new technology—in particular when

[13] Mann-Whitney-Wilcoxon Test: $W = 39874$, $p = 0.6837$. All other distributions are significantly different from each other with a $p < 0.05$.

citizens are informed about its potential negative aspects—it is nevertheless the preferred solution when compared to the alternative of conventional technology. Moreover, although information treatments still influence responses in a significant way, the differences are clearly weaker than absolute attitudes.

--- Fig. 5 about here ---

To test the robustness of the information effects, I conducted several additional analyses. First, I used logistic models to predict the approval of new and hybrid high voltage lines, respectively, to confirm the high relevance mostly of the negative information treatment, which remains strong and significant in the model, even when controlling for previous attitudes, experience, and other individual characteristics (Figure 6). Moreover, the results support the view that information effects differ with respect to the new and the established technology. In the multiple regression models, the information that an increased grid capacity will be necessary to meet future demands does not significantly influence the likelihood of citizen support for the construction of a new line anymore, even though the positive information effect for the new technology remains statistically significant. Individuals who were informed about the necessity for grid expansion are slightly more supportive of converting an existing line into a hybrid one.[14]

--- Fig. 6 about here ---

[14] I also tested for an interaction between the two treatments, which I found was not statistically significant.

Second, based on theoretical considerations, an interaction can be expected between the information treatments and prior experiences and attitudes (e.g., Wood & Vedlitz, 2007). Thus, I also integrated interaction effects between the treatment variables and the individual characteristics to test whether information effects vary, depending on prior attitudes and experiences or other individual characteristics. These analyses revealed that the information effects are highly stable across groups. None of the interaction effects proved to be statistically significant, meaning that the treatment effects do not vary between groups (for an example, see Figure A.2 in the Appendix that illustrates the marginal treatment effects for the varying levels of prior attitudes and experience). Thus, the treatment effects of the main analysis seem to be rather generic— although the level of approval for the different technical solutions is dependent on individual characteristics, the size of the information effect is not.

Third, to test whether information effects are contingent on a specific case, I also analyzed another technology of high voltage electricity transmission—underground cables. It is not the aim of these additional analyses to compare the varying reasons for opposition to these different technologies, but rather to focus on whether similar types of information, i.e., information about the potential negative and positive externalities (Tempesta et al., 2014), have a similar impact on respondents' agreement and disagreement about the two technical solutions. As the additional analyses demonstrate (see Appendix, Figure A.3), information effects can be found with respect to respondents' attitudes towards underground cables, but they seem to be somewhat weaker in comparison to hybrid high voltage lines. The positive treatment produces a small (but still significant) increase in choosing this technology, which may be due to the fact that this technology can build on a generally high approval rate. However, negative information more strongly affects relative attitudes for underground cable as well. Although support for underground cables is exceptionally high in the control group, approval substantially declines when respondents (i.e., the treatment group) are informed about the potential disadvantages of

this new technology. This finding not only confirms a recent study from Switzerland (Lienert et al., 2018), but also supports the view that even if a new technology can build on some previous positive predispositions, new and technical information about negative consequences may substantially impact citizens' opinions.

Conclusions

The present study examined how information influences individual opinions on the technical solutions for electricity transmission, and to what extent a potential information effect differs with respect to new and conventional technologies, and also depends on the framing of the information. Based on an experimental split ballot design, the present study has shown that attitudes towards the new technologies of electricity transmission are very volatile, whereas they are much more stable with regards to the conventional technology of electricity transmission. This finding is reflected by the fact that the information treatments significantly and—in the case of negative information—substantially impacted individual attitudes towards hybrid lines. The negative information treatment was the most important single variable in a model that explained the disapproval of hybrid high voltage lines. Moreover, the information effects were found to be generic, i.e., they were constant across groups. In other words, for example, providing people with information about the potential negative impacts of the new technology of hybrid lines decreases their approval of them, irrespective of whether they live close to an existing line or not, or whether they perceive high voltage lines as disturbing or not.

The present contribution has found that the citizens' of Switzerland generally seem to be rather skeptical about the electricity transmission infrastructure. However, whereas many studies have concluded that visual landscape impacts are the most important reason for opposition against high voltage lines (Devine-Wright & Batel, 2013; Knudsen et al., 2015; Lienert et al., 2017; Tempesta et al., 2014), our data suggest that citizens of Switzerland care more about

health-related issues. Although a comparative perspective has not been the focus of this study, the Swiss political system may provide one explanation for this finding—given the participatory and decentralized characteristic of Switzerland, infrastructure siting processes are typically very political processes, which may be conducive to high voltage lines being a highly predisposed and politicized issue. In view of the presented findings, resistance to high voltage lines in Switzerland cannot be explained consistently by the NIMBY phenomenon, but rather is based on the more fundamental problem that people generally do not like this (new or conventional) technology of electricity transmission (Wolsink, 2000).

Of course, this study has some limitations and opens paths for future research. One drawback of the study design is that I could not explicitly test whether negative (instead of positive) information has an effect on attitudes regarding the conventional technology. Similarly, for the control case (underground cable), only data on relative, but not absolute, attitudes were available. Moreover, the positive treatment was fashioned at a more abstract and general level than the negative treatment, which specifically informed respondents about the negative consequences of the new technology. This difference may underestimate the effect of the positively framed information treatment. Thus, the data the present study used did not allow for an encompassing and systematic test of absolute and relative attitudes towards the different technical solutions, and the negatively and positively framed information. Nevertheless, the available data produced quite stable results, which implies that the differences between the new and conventional technologies, and also between the positive and negative information, should be considered so to better understand citizens' opinions on these issues. A second limitation concerns the question as to whether the treatment effects found in a survey are mainly short-term and measurement effects, or whether they have the potential to become long-lasting, and thus substantially and politically relevant. Hence, in future research, e.g., using a panel design, it would be highly relevant to see how positive and negative information treatments persist over

time. Similarly, comparative studies should investigate how the country context systematically influences the level of acceptance, and also the relevance of information effects. Third, the level of approval for the different technical solutions for electricity transmission was studied in a hypothetical survey context, and from the perspective of socio-political acceptance, i.e., regarding the technology as such. Therefore, a conclusion should not be draw that similarly high acceptance rates will be found in a real-world local project, i.e., with respect to community acceptance (Dermont et al., 2017; Wüstenhagen et al., 2007).

Notwithstanding these limitations, the results of the present study have policy-related and methodological implications that may be relevant not only for the technical solutions for electricity transmission, but also—given the many similarities—for energy-related infrastructure more generally.

Methodologically, the present study shows that experimental survey elements may be a way to anticipate how individual self-reported attitudes in surveys—but perhaps also in reality—are substantially influenced by the context, e.g., question wording and framing. In other words, by explicitly exposing respondents to varying explicit (or implicit) information, the present study was able to capture the volatility in attitudes. This strategy helps to avoid wrong conclusions about a massive level of "acceptance" for hybrid power lines or energy technologies in a specific survey context, e.g., when people are informed only partially about advantages and disadvantages of a new technology.

At the policy level, and especially with respect to a context of new technology, I found that citizens, independently of previous attitudes and experiences, are very reactive to negatively-framed information that substantiates their latent fears. This result is important for policy makers, especially in a participatory context in which citizens directly participate in (local) decision-making processes. It implies that the acceptance of new technologies is highly suscep-

tible to “negative campaigning” by opponents who emphasize the disadvantages of a technological solution (Gross 2007; van der Horst 2007; Wolsink 2000). Moreover, the present study also points out that negative information cannot be compensated easily by general positive information. For example, it is *not* enough to only tell people that grid capacity is necessary to meet future demands; rather, the proponents of new technologies must do more. These findings highlight the importance of procedural aspects, and in particular of designing and planning siting projects to be participatory, inclusive processes (Aas et al., 2014; Bidwell, 2016; Gross, 2007; Knudsen et al., 2015; Soini et al., 2011). In this context, previous studies have emphasized the role of citizens’ involvement and information mostly in terms of representation, i.e., that different interests and needs must be integrated at an early stage. Although such bottom-up and inclusive processes are expected to lead to perceptions of fairness and equality, and thus to higher social acceptance (Gross, 2007; Knudsen et al., 2015), some research has found that from the perspective of policy makers, this kind of grassroots inclusivity typically is seen “as compulsory exercises, undertaken more of duty and less with a goal to involve and listen to local publics” (Knudsen et al., 2015, p. 307). The results presented in the present study provide a more strategic motivation for policy makers to plan siting processes in an open and inclusive way. Most importantly, this strategy is necessary because the opponents of a project have a systematic advantage: their information about the negative consequences of a project will generally be more powerful in the debate compared to the arguments of the proponents of a project—rather independently of whether the arguments are appropriate or not. Thus, integrating potential opponents at an early stage and trying to find good compromises are not only a matter of being nice, but also involve substantial benefits for successful implementation. On the one hand, the creation of an open and broad discussion and information on electricity transmission and renewable electricity production, as well as on the advantages and disadvantages of various technological alternatives, may provide knowledge for all concerned actors. Moreover, talking about alternatives may facilitate public openness to change, not least of all by acknowledging

that doing nothing is not a reasonable option in many situations. On the other hand, the strong effect of negative information also demonstrates that policy makers need to work out good projects. Integrating the various interests and perspectives at an early stage probably will help to avoid projects that are criticized and opposed for good reasons (see Aitken, 2010). In addition, this open approach also points to the importance of cooperation and interaction between technical and political viewpoints. In fact, the relevance of negative information to public opinion also implies that the technological advancements to reduce the potential drawbacks and uncertainties of new technologies may be an important trigger for citizens' approval, and thus the *political* implementation of these technologies. The fewer technical drawbacks that exist (and the less uncertainty about potential negative effects), the less reasons citizens have to oppose a project politically.

Acknowledgement

This research has been funded by the Swiss National Science Foundation within the framework of the National Research Programme (NRP) 71 "Managing Energy Consumption". I thank the participants of the working group "Representation andPolitical Behaviour" at the Annual Conference of the Swiss Political Science Association 2017, especially Celine Colombo, as well as the three anonymous reviewers for helpful comments on previous versions of this paper. Moreover, I thank Wayne Egers for linguistic assistance.

References

Aas, Ø., Devine-Wright, P., Tangeland, T., Batel, S., & Ruud, A. (2014). Public beliefs about high-voltage powerlines in Norway, Sweden and the United Kingdom: A comparative

survey. *Energy Research & Social Science*, *2*, 30–37. https://doi.org/10.1016/j.erss.2014.04.012

Ackermann, T., Andersson, G., & Söder, L. (2001). Distributed generation: a definition. *Electric Power Systems Research*, *57*(3), 195–204. https://doi.org/10.1016/S0378-7796(01)00101-8

Aitken, M. (2010). Why we still don't understand the social aspects of wind power: A critique of key assumptions within the literature. *Energy Policy*, *38*, 1834–1841. https://doi.org/10.1016/j.enpol.2009.11.060

Batel, S., & Devine-Wright, P. (2015). Towards a better understanding of people's responses to renewable energy technologies: Insights from Social Representations Theory. *Public Understanding of Science*, *24*(3), 311–325. https://doi.org/10.1177/0963662513514165

Batel, S., Devine-Wright, P., & Tangeland, T. (2013). Social acceptance of low carbon energy and associated infrastructures: A critical discussion. *Energy Policy*, *58*, 1–5. https://doi.org/10.1016/j.enpol.2013.03.018

Bell, D., Gray, T., & Haggett, C. (2005). The "social gap" in wind farm siting decisions: Explanations and policy responses. *Environmental Politics*, *14*(4), 460–477. https://doi.org/10.1080/09644010500175833

Bell, D., Gray, T., Haggett, C., & Swaffield, J. (2013). Re-visiting the 'social gap': public opinion and relations of power in the local politics of wind energy. *Environmental Politics*, *22*(1), 115–135. https://doi.org/10.1080/09644016.2013.755793

Berelson, B., Lazarsfeld, P. F., & McPhee, W. N. (1986). *Voting : a study of opinion formation in a presidential campaign*. University of Chicago Press. Retrieved from https://books.google.ch/books?hl=de&lr=&id=Iux07CCye5QC&oi=fnd&pg=PA3&dq=

Voting:+A+Study+of+Opinion+Formation+in+a+Presidential+Campaign&ots=zq-jfkhCDH&sig=zFUi45A5NRF0-hZkMqxcrN1eD_U#v=onepage&q=Voting%3A A Study of Opinion Formation in a Presidential Ca

Bidwell, D. (2016). Thinking through participation in renewable energy decisions. *Nature Energy*, *1*(5), 16051. https://doi.org/10.1038/nenergy.2016.51

Braunholtz, S., & McWhannell, F. (2003). *Public attitudes to windwarms. A survey of local residents in Scotland*. Edinburgh. Retrieved from http://www.gov.scot/Resource/Doc/47133/0014639.pdf

Chong, D., & Druckman, J. N. (2007). Framing Theory. *Annual Review of Political Science*, *10*(1), 103–126. https://doi.org/10.1146/annurev.polisci.10.072805.103054

Ciupuliga, A. R., & Cuppen, E. (2013). The role of dialogue in fostering acceptance of transmission lines: The case of a France-Spain interconnection project. *Energy Policy*, *60*, 224–233. https://doi.org/10.1016/j.enpol.2013.05.028

Cohen, J., Moeltner, K., Reichl, A., & Schmidthaler, M. (2016). An empirical analysis of local opposition to new transmission lines across the EU-27. *Energy Journal*, *37*(3), 59–82. https://doi.org/10.5547/01956574.37.3.jcoh

Converse, P. (1964). The nature of belief systems in mass publics. In D. Apter (Ed.), *Ideology and Discontent* (pp. 206–261). New York: Free.

de Best-Waldhober, M., Daamen, D., & Faaij, A. (2009). Informed and uninformed public opinions on CO2capture and storage technologies in the Netherlands. *International Journal of Greenhouse Gas Control*, *3*(3), 322–332. https://doi.org/10.1016/j.ijggc.2008.09.001

Dermont, C., Ingold, K., Kammermann, L., & Stadelmann-Steffen, I. (2017). Bringing the

policy making perspective in: A political science approach to social acceptance. *Energy Policy*, *108*(July 2016), 359–368. https://doi.org/10.1016/j.enpol.2017.05.062

Devine-Wright, P. (2005). Beyond NIMBYism: Towards an integrated framework for understanding public perceptions of wind energy. *Wind Energy*, *8*(2), 125–139. https://doi.org/10.1002/we.124

Devine-Wright, P. (2011). Enhancing local distinctiveness fosters public acceptance of tidal energy: A UK case study. *Energy Policy*, *39*(1), 83–93. https://doi.org/10.1016/j.enpol.2010.09.012

Devine-Wright, P. (2013). Explaining "NIMBY" Objections to a Power Line. The Role of Personal, Place Attachment and Project-Related Factors. *Environment and Behavior*, *45*(6), 761–781. https://doi.org/10.1177/0013916512440435

Devine-Wright, P., & Batel, S. (2013). Explaining public preferences for high voltage pylon designs: An empirical study of perceived fit in a rural landscape. *Land Use Policy*, *31*, 640–649. https://doi.org/10.1016/J.LANDUSEPOL.2012.09.011

Dondi, P., Bayoumi, D., Haederli, C., Julian, D., & Suter, M. (2002). Network integration of distributed power generation. *Journal of Power Sources*, *106*, 1–9. Retrieved from https://ac.els-cdn.com/S037877530101031X/1-s2.0-S037877530101031X-main.pdf?_tid=162e026a-0731-11e8-b551-00000aacb35d&acdnat=1517476984_10e77fab262d561d202d5195ad2f549f

Druckman, J. N. (2004). Political Preference Formation: Competition, Deliberation, and the (Ir)relevance of Framing Effects. *American Political Science Review*, *98*(04), 671–686. https://doi.org/10.1017/S0003055404041413

Ek, K. (2005). Public and private attitudes towards "green" electricity: The case of Swedish

wind power. *Energy Policy*, *33*(13), 1677–1689. https://doi.org/10.1016/j.enpol.2004.02.005

ENTSO-E. (2014). *10-Year Network Development Plan 2014*. Retrieved from https://www.entsoe.eu/major-projects/ten-year-network-development-plan/tyndp-2014/Documents/ TYNDP 2014_FINAL.pdf (retrieved July 7, 2017).

Federal Council. (2013). *Strategie Stromnetze; Detailkonzept im Rahmen der Energiestrategie 2050*. Bern.

Firestone, J., Kempton, W., Lilley, M. B., & Samoteskul, K. (2012). Public acceptance of offshore wind power across regions and through time. *Journal of Environmental Planning and Management*, *55*(10), 1369–1386. https://doi.org/10.1080/09640568.2012.682782

Fleishman, L. A., De Bruin, W. B., & Morgan, M. G. (2010). Informed public preferences for electricity portfolios with CCS and other low-carbon technologies. *Risk Analysis*, *30*(9), 1399–1410. https://doi.org/10.1111/j.1539-6924.2010.01436.x

Gross, C. (2007). Community perspectives of wind energy in Australia: The application of a justice and community fairness framework to increase social acceptance. *Energy Policy*, *35*(5), 2727–2736. https://doi.org/10.1016/j.enpol.2006.12.013

Hansen, K. M. (2007). The Sophisticated Public: The Effect of Competing Frames on Public Opinion. *Scandinavian Political Studies*, *30*(3), 377–396. https://doi.org/10.1111/j.1467-9477.2007.00185.x

Hedtke, S., Pfeiffer, M., Gaillard, A., & Franck, C. M. (2016). Effect of electrostatic induction and space charges on the audible corona noise of hybrid AC/DC transmission lines. In *CI-GRE IEC Conference on EHV & UHV, Montreal.*

Hopmann, D. N., Vliegenthart, R., De Vreese, C., & Albæk, E. (2010). Effects of Election News Coverage: How Visibility and Tone Influence Party Choice. *Political Communication*, *27*(4), 389–405. https://doi.org/10.1080/10584609.2010.516798

Itaoka, K., Okuda, Y., Saito, A., & Akai, M. (2009). Influential information and factors for social acceptance of CCS: The 2nd round survey of public opinion in Japan. *Energy Procedia*, *1*(1), 4803–4810. https://doi.org/10.1016/j.egypro.2009.02.307

Jacoby, W. G. (2000). Issue Framing and Public Opinion on Government Spending. *American Journal of Political Science*, *44*(4), 750–767. Retrieved from http://www.jstor.org/stable/2669279

Jobert, A., Laborgne, P., & Mimler, S. (2007). Local acceptance of wind energy: Factors of success identified in French and German case studies. *Energy Policy*, *35*(5), 2751–2760. https://doi.org/10.1016/j.enpol.2006.12.005

Kahneman, D., & Tversky, A. (1979). Prospect Theory: An Analysis of Decision Under Risk. *Econometrica*, *47*, 263–297. https://doi.org/10.1142/9789814417358_0006

Knippenberg, D. v., & Daamen, D. (1996). Providing information in public opinion surveys: Motivation and ability effects in the information-and-choice questionnaire. *International Journal of Public Opinion Research*, *8*(1), 70–82. https://doi.org/10.1093/ijpor/8.1.70

Knudsen, J. K., Wold, L. C., Aas, Ø., Kielland Haug, J. J., Batel, S., Devine-Wright, P., … Jacobsen, G. B. (2015). Local perceptions of opportunities for engagement and procedural justice in electricity transmission grid projects in Norway and the UK. *Land Use Policy*, *48*, 299–308. https://doi.org/10.1016/J.LANDUSEPOL.2015.04.031

Lienert, P., Sütterlin, B., & Siegrist, M. (2017). The influence of high-voltage power lines on the feelings evoked by different Swiss surroundings. *Energy Research & Social Science*,

23, 46–59. https://doi.org/10.1016/J.ERSS.2016.11.010

Lienert, P., Sütterlin, B., & Siegrist, M. (2018). Public acceptance of high-voltage power lines: The influence of information provision on undergrounding. *Energy Policy*, *112*, 305–315. https://doi.org/10.1016/j.enpol.2017.10.025

Lutz, G. (2016). *Eidgenössische Wahlen 2015. Wahlteilnahme und Wahlentscheid*. Lausanne.

McDermott, R. (2004). Prospect Theory in Political Science: Gains and Losses From the First Decade. *Political Psychology*, *25*(2), 289–312. https://doi.org/10.1111/j.1467-9221.2004.00372.x

Mercer, J. (2005). Prospect Theory and Political Science. *Annual Review of Political Science*, *8*(1), 1–21. https://doi.org/10.1146/annurev.polisci.8.082103.104911

Nelson, T. E., Oxley, Z. M., & Clawson, R. A. (1997). Toward a Psychology of Framing Effects. *Political Behavior*, *19*(3), 221–246. https://doi.org/10.1023/A:1024834831093

O'Garra, T., Mourato, S., & Pearson, P. (2005). Analysing awareness and acceptability of hydrogen vehicles: A London case study. *International Journal of Hydrogen Energy*, *30*(6), 649–659. https://doi.org/10.1016/j.ijhydene.2004.10.008

Palmgren, C. R., & Keith, D. W. (2004). Policy Analysis Initial Public Perceptions of Deep Geological and Oceanic Disposal of Carbon Dioxide. *Environmental Science and Technology*, (JANUARY), 6441–6450. https://doi.org/10.1021/es040400c

Reiner, D. M., Curry, T. E., De Figueiredo, M. A., Herzog, H. J., Ansolabehere, S. D., Itaoka, K., … Odenberger, M. (2006). American exceptionalism? Similarities and differences in national attitudes toward energy policy and global warming. *Environmental Science and Technology*, *40*(7), 2093–2098. https://doi.org/10.1021/es052010b

Ricci, M., Bellaby, P., & Flynn, R. (2008). What do we know about public perceptions and acceptance of hydrogen? A critical review and new case study evidence. *International Journal of Hydrogen Energy*, *33*(21), 5868–5880. https://doi.org/10.1016/j.ijhydene.2008.07.106

Schulte, I., Hart, D., & Van der Vorst, R. (2004). Issues affecting the acceptance of hydrogen fuel. *International Journal of Hydrogen Energy*, *29*(7), 677–685. https://doi.org/10.1016/j.ijhydene.2003.09.006

Shah, D. V., Watts, M. D., Domke, D., & Fan, D. P. (2002). News Framing and Cueing of Issue Regimes. *Public Opinion Quarterly*, *66*(3), 339–370. https://doi.org/10.1086/341396

Slothuus, R., & Vreese, C. H. de. (2010). Political Parties, Motivated Reasoning, and Issue Framing Effects. *Journal of Political Economy*, *72*(630–645). https://doi.org/10.1017/S002238161000006X

Soini, K., Pouta, E., Salmiovirta, M., Uusitalo, M., & Kivinen, T. (2011). Local residents' perceptions of energy landscape: The case of transmission lines. *Land Use Policy*, *28*(1), 294–305. https://doi.org/10.1016/j.landusepol.2010.06.009

Swissgrid. (2017). Erdverkabelung im Höchstspannungsnetz. Retrieved July 12, 2017, from https://www.swissgrid.ch/dam/swissgrid/company/publications/de/erdverkabelung_HSN_de.pdf

Taber, C. S., & Lodge, M. (2006). Motivated Skepticism in the Evaluation of Political Beliefs. *American Journal of Political Science*, *50*(3), 755–769. https://doi.org/10.1111/j.1540-5907.2006.00214.x

Tempesta, T., Vecchiato, D., & Girardi, P. (2014). The landscape benefits of the burial of

high voltage power lines: A study in rural areas of Italy. *Landscape and Urban Planning*, *126*, 53–64. https://doi.org/10.1016/J.LANDURBPLAN.2014.03.003

Warren, C. R., Lumsden, C., O'Dowd, S., & Birnie, R. V. (2005). "Green on green": Public perceptions of wind power in Scotland and Ireland. *Journal of Environmental Planning and Management*, *48*(6), 853–875. https://doi.org/10.1080/09640560500294376

Wolsink, M. (2000). Wind Power and the NIMBY-Myth : Institutional Capacity and the Limited Signicance of Public Support. *Renewable Energy*, *21*(September 2000), 49–64. https://doi.org/10.1016/S0960-1481(99)00130-5

Wolsink, M. (2007). Planning of renewables schemes: Deliberative and fair decision-making on landscape issues instead of reproachful accusations of non-cooperation. *Energy Policy*, *35*(5), 2692–2704. https://doi.org/10.1016/j.enpol.2006.12.002

Wood, B. D., & Vedlitz, A. (2007). Information Processing, and the Politics of Global Warming. *American Journal of Political Science*, *51*(3), 552–568. https://doi.org/10.1111/j.1540-5907.2007.00267.x

Wüstenhagen, R., Wolsink, M., & Bürer, M. J. (2007). Social acceptance of renewable energy innovation: An introduction to the concept. *Energy Policy*, *35*(5), 2683–2691. https://doi.org/10.1016/j.enpol.2006.12.001

Zaller, J. (1992). *The Nature and Origins of Mass Opinion*. New York: Cambridge University Press.

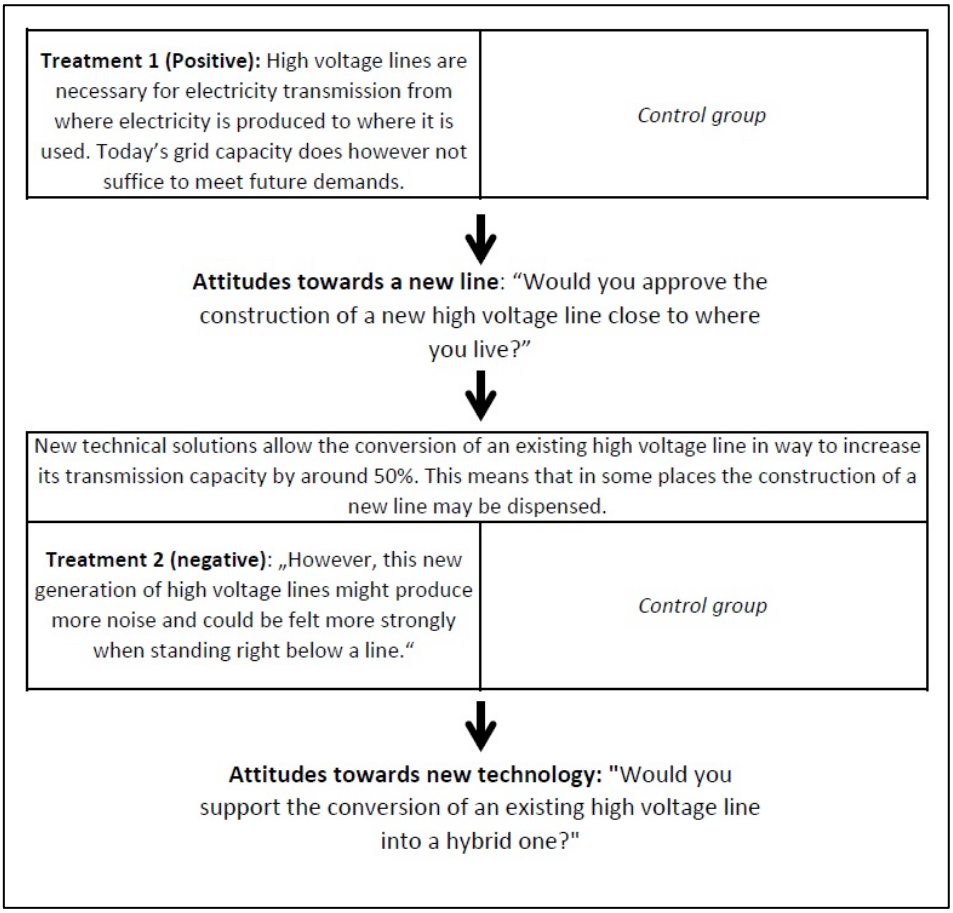

Figure 1. **Design of the information treatments.**

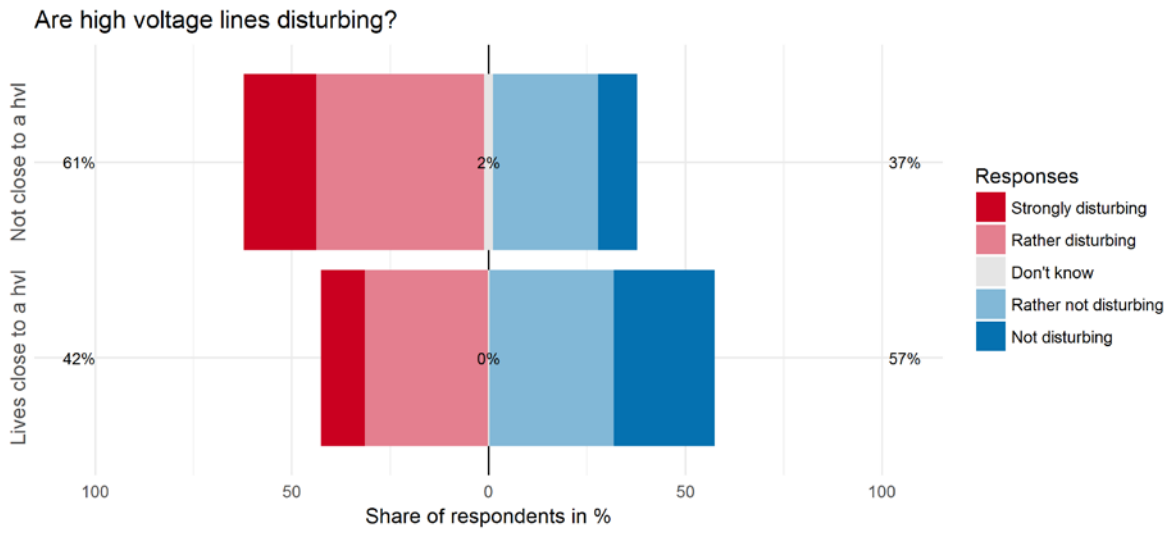

Figure 2. **How disturbing do you think are high voltage lines?** Note: Share of respondents in % per category. According to the Mann-Whitney-Wilcoxon test, the distribution between the two groups is statistically significant (W = 170’370, $p < 0.001$).

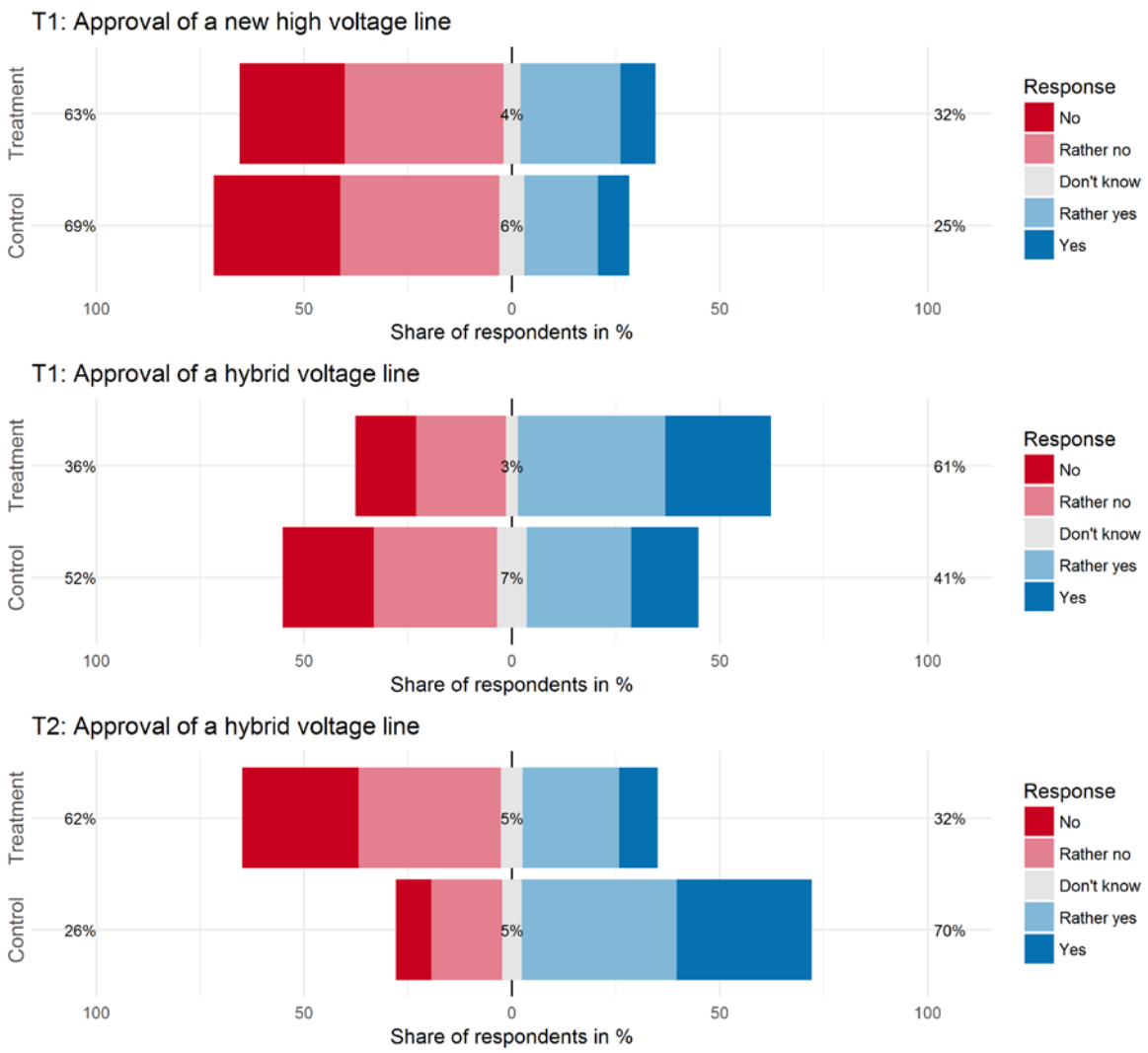

Figure 3. **Approval of a new or hybrid high voltage line close to a living place.** Differences between the treatment and control groups; T1 = treatment 1, T2 = treatment 2; Share of respondents by category. According to the Mann-Whitney-Wilcoxon tests, all the differences between the treatment and control groups are statistically significant with a $p < 0.05$.

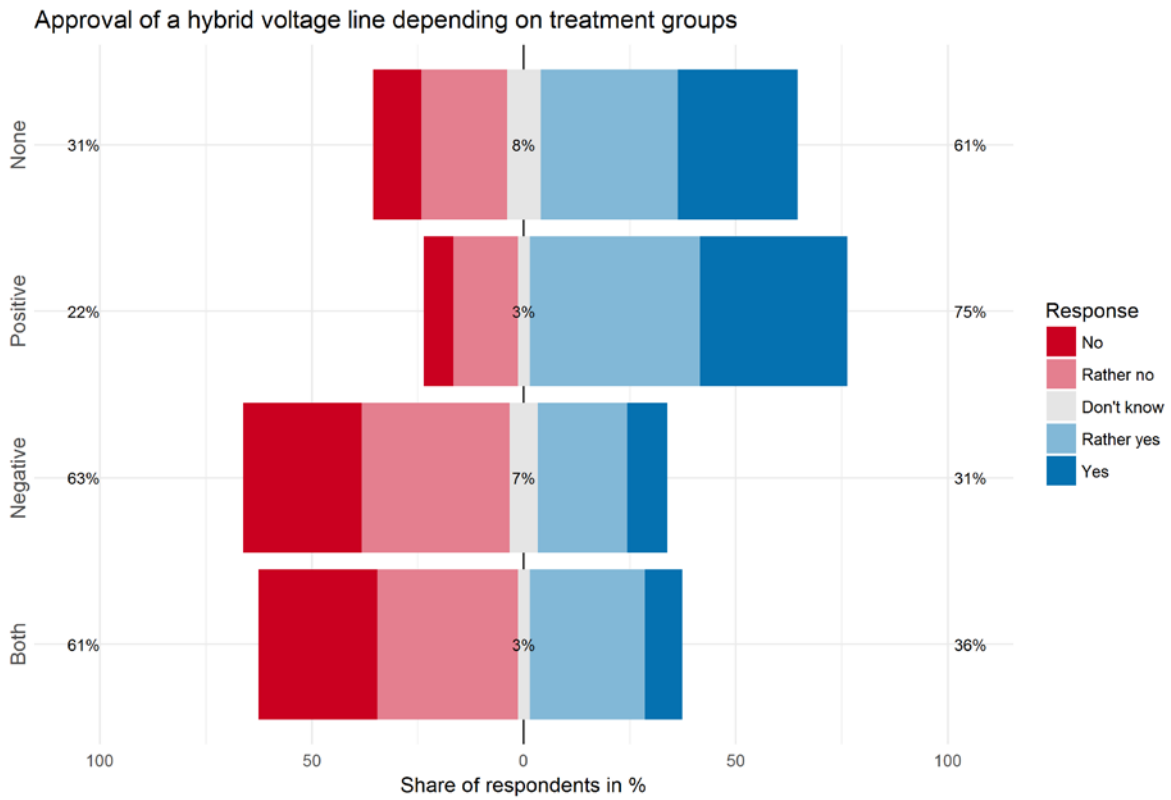

Figure 4. **Approval of a hybrid high voltage line close to a living place.** Differences between treatment and control groups; None = Received no information treatment; Positive = received only positive treatment; Negative = received only negative treatment; Both = received both treatments; Share of respondents by category. According to the Mann-Whitney-Wilcoxon tests, all group differences but the differences between "Both" and "Negative", and between "None" and "Positive" are statistically significant with a $p<0.001$.

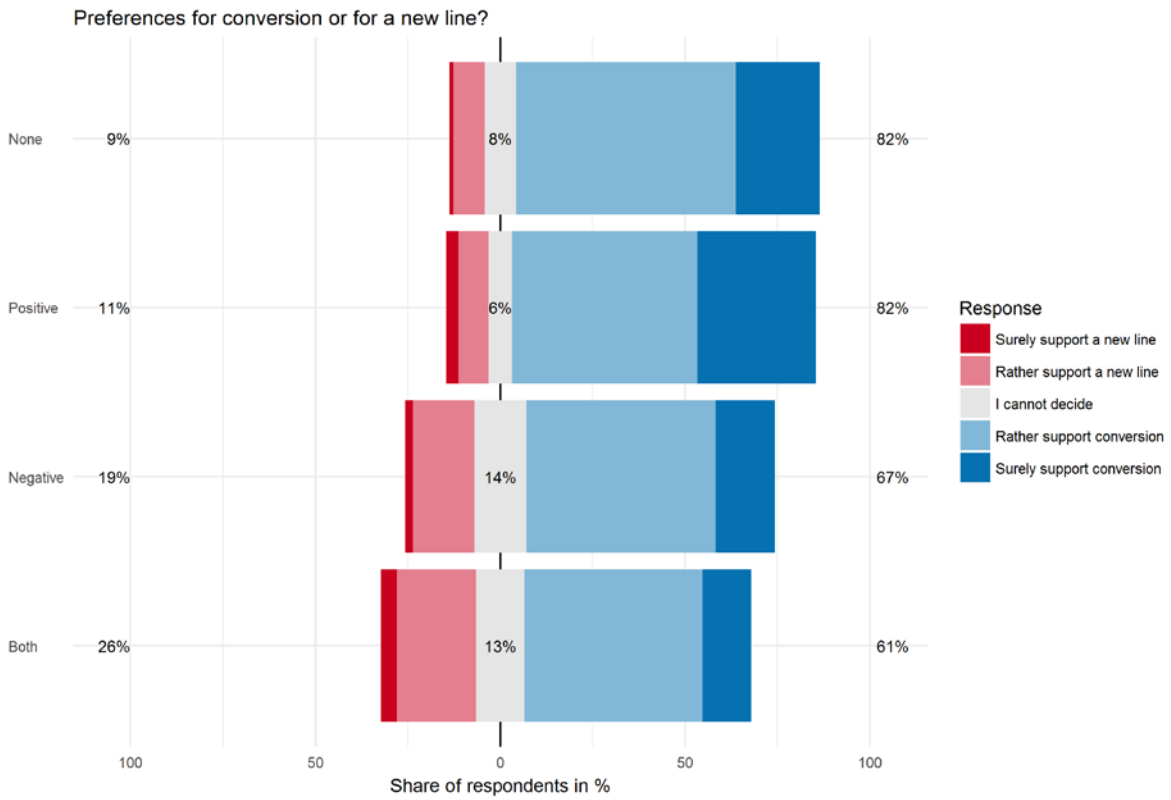

Figure 5. **Relative attitudes for hybrid high voltage lines, compared to conventional overhead lines.** Differences between the treatment and control groups; None = received no information treatment; Positive = received only a positive treatment; Negative = received only a negative treatment; Both = received both treatments; Share of respondents by category. According to the Mann-Whitney-Wilcoxon tests, all group differences but the difference between "None" and "Positive" as well as between "Negative" and "Both" are statistically significant with a $p < 0.05$.

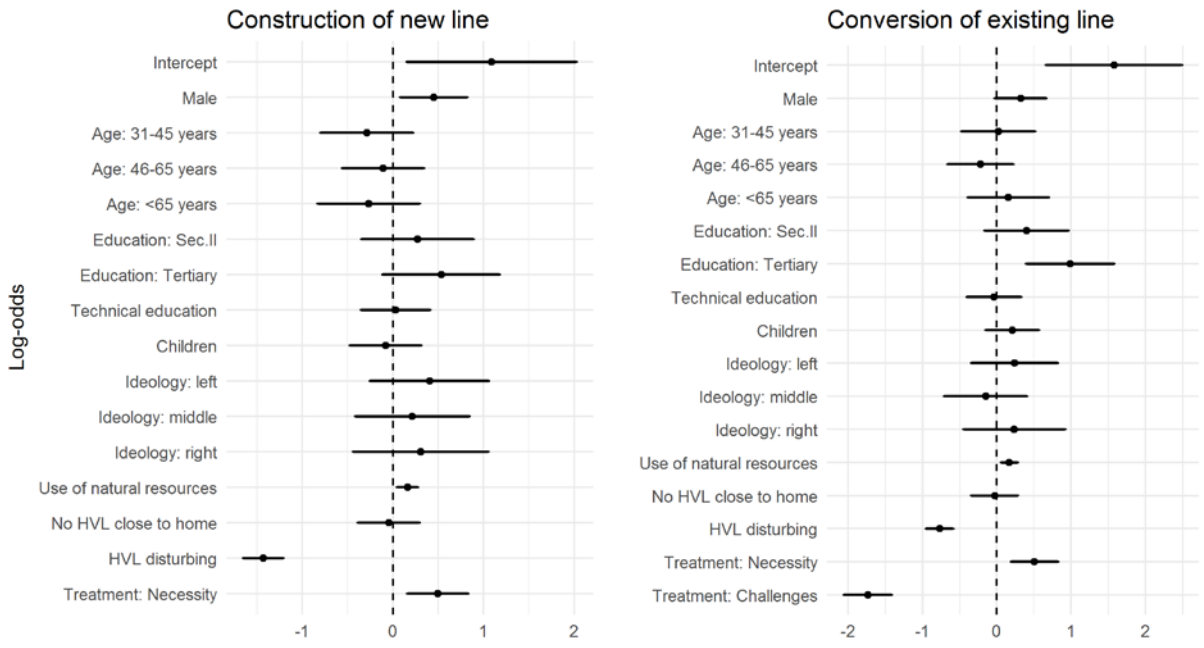

Figure 6. **Logit models to predict attitudes concerning the construction of a new line and the conversion of an existing line, respectively.** Log odds, 95% confidence intervals presented.

Appendix

Table A.1

Variables, Summary Statistics, and Operationalization

Variable	Summary statistics	Operationalization	Distributions in the Swiss population*
Dependent variables			
Approval of a new conventional high voltage line	Yes = 8.7% Rather Yes = 22.5% Rather No = 38.7% No = 30.1%	Would you support the construction of a new high voltage line near where you live? Four categories: Yes, rather yes, rather no, no.	
Approval of a converted, hybrid high voltage line	Yes = 19.2% Rather Yes = 24.6% Rather No = 33.4% No = 22.8%	Would you support the conversion of an existing high voltage line to a hybrid one? Four categories: Yes, rather yes, rather no, no.	
Explanatory variables			
HVL disturbing (prior attitudes)	Disturbing =15.7% Rather disturbing = 38.3% Rather not disturbing = 28.8% Not disturbing = 17.3%	In general, how disturbing do you think are high voltage lines? Four categories: Disturbing, rather disturbing, rather not disturbing, not disturbing.	
No HVL close (prior experience)	Lives close = 47.6% No HVL close = 52.4%	Self-reported closeness to high voltage lines. Dummy: 1 = individual does not live close (around 1km) to a high voltage line; 0 = individual lives close to a high voltage line (reference category).	
Male	Male = 53.9% Female = 46.1%	Gender dummy: 1 = male (reference category); 0 = female.	Male = 49.2% Female = 50.8.1%

Education	Lower secondary = 8.7% Higher secondary = 48.5% Higher tertiary = 42.8%	Three categories: Lower secondary (reference category), higher secondary, tertiary education.	Lower secondary = 12.1% Higher secondary = 46.3% Higher tertiary = 41.6%
Age	<31 y. = 19.0% 31-45y. = 27.2% 46-65y. = 38.9% >65y, = 14.9%	Four categories: Younger than 31 years (reference category), 31–45 years old, 46–65 years old, older than 65 years.	
Left-right placement	Left = 24.1% Middle = 44.7% Right = 12.0% Don't know = 9.2%	Political self-placement; four categories: Left, middle, right, no position (reference category).	Left = 23.6% Middle = 33.8% Right = 33.7% Don't know = 9.2%
Use of natural resources	Mean = 2.89 S.D. = 1.44 Min. = 1 Max. = 6	Response to the following question: Do you prefer that in Switzerland, nature and landscape protection is more important than the use of natural resources; or would you rather prefer that the economic use of natural resources is prioritized over nature and landscape protection? Scale from 1 (Priority of nature/landscape protection) to 6 (Priority of the economic use of natural resources).	
Technical education	Has technical form. = 35.0% No technical formation = 65%	Dummy: 1 = individual has a technical formation; 0 = Individual does not have a technical formation (reference category).	
Children in household	Has children = 32.0% No children = 68%	Dummy: 1 = with children; 0 = without children (reference category).	
Treatment 1: Necessity	Treatment = 50.7% Control = 49.3%	Treatment: High voltage lines are necessary for electricity transmission from where electricity is produced to where it is used. Today's grid capacity, however, will not be able to meet future demands. Dummy: 1 = Treatment group; 0 = Control Group (Reference category).	

Treatment 2: Challenges	Treatment = 49.2% Control = 50.8%	Treatment: However, this new generation of high voltage lines may produce more noise and could be felt more strongly when standing directly underneath a line. Dummy: 1 = Treatment group; 0 = Control Group (Reference category).	

*The socio-demographic characteristics are from the representative sample provided by the Federal Office of Statistics. The data for the educational level are from Swiss Labour Force Statistics (2015). The left-right placement is calculated based on the Swiss Electoral Study 2015 (Lutz 2016).

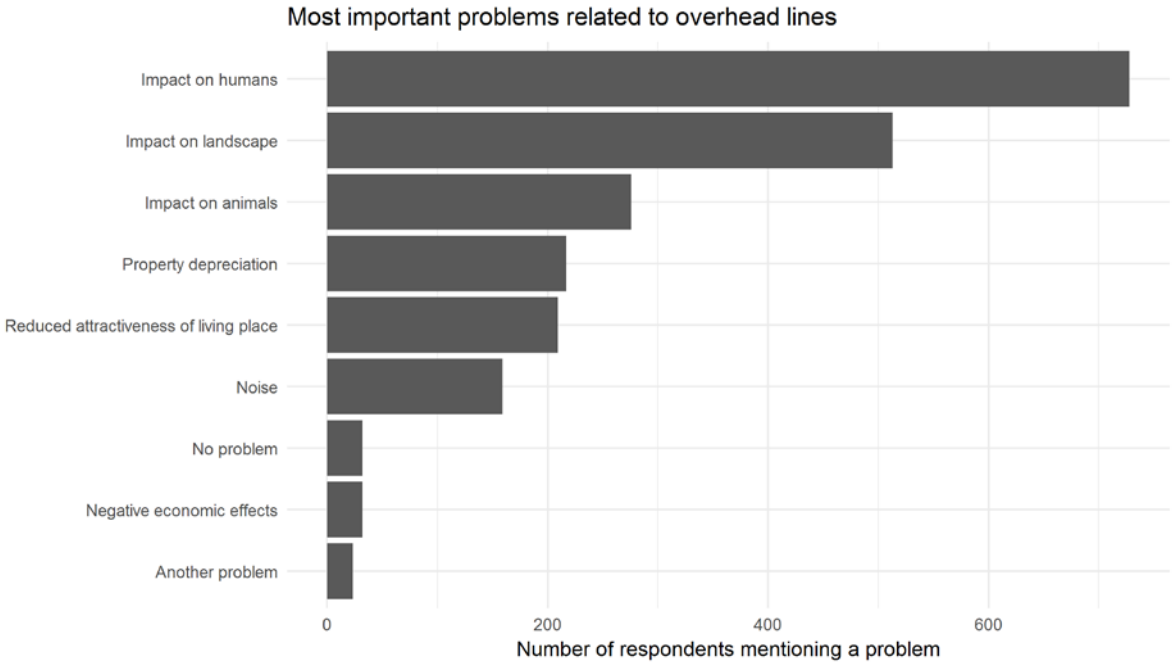

Figure A.1. **Most important problems related to overhead lines**. Each respondent had to choose two main problems from a pre-defined list. Note that similar results were obtained by the Swissgrid Stakeholder Survey 2016, in which a similar question was used, but based on an open question format.

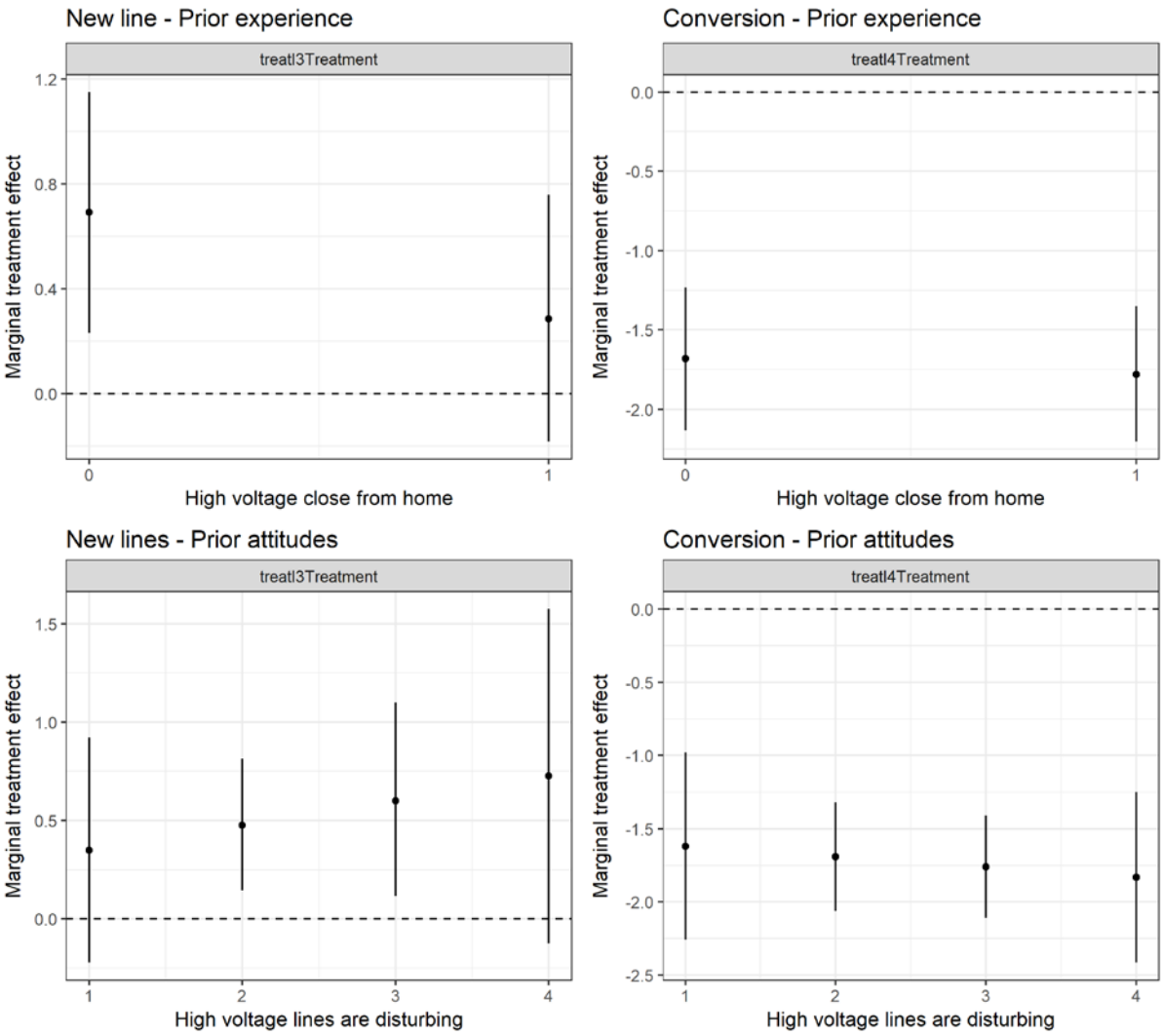

Figure A.2. **Marginal effect plot based on logistic regression models as shown in Figure 6, which includes additional interactions between the information treatment and prior attitudes towards high voltage lines.**

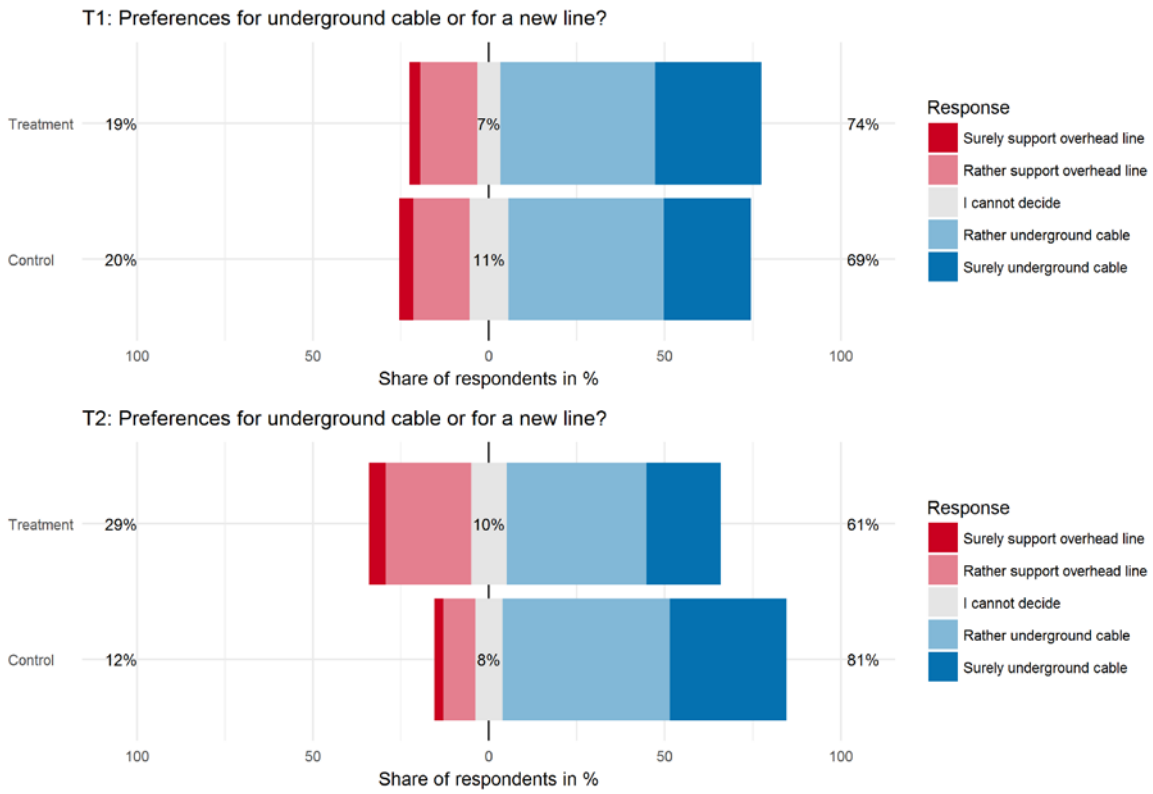

Figure A.3. **Relative attitudes towards the construction of an underground cable or a new line.** Question wording: Do you think additional grid capacity should be generated through (new or converted) overhead high voltage lines, or would you rather prefer the use of underground cables? T1 = treatment 1 (positive, see previous analyses), T2 = a negative treatment regarding underground cables: „However, this last variant is more expensive and when being constructed generates broad traces (like a highway) that subsequently cannot be used to plant deep-rooted and high-stock trees (e.g., forest, fruit trees).“ Share of respondents by category. According to the Mann-Whitney-Wilcoxon tests, group differences are significant with respect to both treatments (T1: $W = 164110$, $p = 0.03$; T2: $W = 217190$, $p < 0.001$).