Decomposing Public Support for Energy Policy: What Drives Acceptance of and Intentions to Protest against Renewable Energy Expansion in Germany?

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Abstract: Based on data from a large-scale survey (n=3,400) conducted in Germany, we analyze citizens' acceptance and protest intentions regarding the construction of new power plants for renewable energy production. We differentiate between wind energy, solar energy, and biomass energy; natural gas is used as a reference category. We measure protest intentions and acceptance regarding the construction of new power plants within a 10-kilometer radius of respondents' place of residence. Protest and acceptance are explained by several competing theoretical determinants such as specific attitudes towards each energy source, general attitudes towards climate change, social norms, the "not-in-my-backyard" phenomenon, place attachment, and conditional cooperation. We use decomposition models used in labor market research to study endowment, discrimination, and characteristics effects related to different attitudinal dimensions and their influence on acceptance and protest intentions. Our results show more positive attitudes, less protest intentions, and a stronger acceptance of solar energy, followed by wind energy, biomass energy, and natural gas. Theory comparison reveals, for instance, that "not-in-my-backyard" beliefs have high explanatory power, climate change concern is only relevant for the acceptance of wind energy and solar energy, and place attachment seems to be a useful concept for explaining protests intentions. The decomposition models indicate that attitudes are strong determinants of acceptance and protest intentions where, in addition to endowment effects, we also find some indications of discrimination effects (i.e., different weights of attitudinal dimensions) and characteristics effects (i.e., effects of respondents' characteristics). Finally, we discuss the policy implications of these results.

Keywords: Attitudes; conditional cooperation; decomposition models; not-in-my-backyard; place attachment; protest; renewable energy

1 Introduction

Nowadays, climate change and its drastic effects on the livelihoods of many societies are largely accepted worldwide. Therefore, the majority of the world community pledged to limit global warming to below two degrees Celsius by ratifying the Paris Agreement dated 2015. Renewable energy expansion is considered to be a cornerstone of climate protection strategies by many governments. The Federal Government of Germany, for instance, has committed itself to a substantial increase in the share of renewables in electricity consumption: While renewables contributed 27 percent in 2014 ,their share is aimed to account for 40 percent by 2025 and at least 80 percent in 2050 (BMWi 2015). Furthermore, the German Advisory Council on the Environment (SRU 2011) stated that Germany can be supplied with 100-percent climate-friendly electricity from renewable sources by 2050.

However, renewable energy does not only have positive effects on the environment and society. It also brings negative consequences such as loss of biodiversity, change of landscapes, etc. Local opposition might limit renewable energy expansion despite strong general public support. When renewables are promoted to achieve climate protection goals, the negative impacts that might arise as a result of citizens' concerns tend to be neglected. Yet it is an empirical question how strong local support, opposition, and the protest potential are and where they originate from.

In this paper, we analyze both acceptance of and protest intention towards the hypothetical construction of new renewable energy power plants in the vicinity of individuals' place of residence. Taking Germany as an example, the aim of our study is to explore what factors affect acceptance of hypothetical new power plants in respondents' surroundings as well as protest intentions towards the construction of new power plants. We consider the renewables wind energy, solar energy, and biomass energy. In addition, we include natural gas as a non-renewable power source. Our study contributes to the literature in two ways. First, we use and compare different theories in order to explain acceptance and protest intentions. The effects of theoretical determinants are frequently overestimated because neither rival nor complementary explanations are tested (e.g., Liebe et al. 2011). The theoretical approaches in our study comprise attitudes, social norms, "not-in-my-backyard" (NIMBY) beliefs, collective action, and place identity/attachment. Second, following Ansolabehere and Konisky (2009), we apply the Blinder-Oaxaca decomposition method (Blinder 1973; Oaxaca 1973), commonly used in labor market research, to establish to what extent differences in the acceptability of power plants can be attributed to “endowment effects,” “discrimination effects,” and “characteristics effects.” These effects enable us to differentiate pure attitudinal evaluation (endowment effects) from “preferences” for certain renewables due to the different weighting of attitudinal evaluation (discrimination effects). Characteristics effects refer to the relevance of respondents’ sociodemographic context.

In the following, we first discuss the theoretical approach used, followed by a description of our data and variables. We then present our results and end with a discussion and conclusion.

2 Theoretical background

2.1 Decomposing public support based on competing theories

We consider several theoretical determinants to explain both the acceptance of and protest intentions towards the development of renewable energy sites (see, for example, Huijts et al. 2012; Bidwell 2013; Perlaviciute and Steg 2014 for reviews). These determinants are derived from different sociological, social-psychological, and economic theories that are of relevance for the explanation of acceptance and protest intentions. On the one hand, these theories complement each other in explaining the complex explananda at hand. On the other hand, by comparing different theories we are able to find out which theoretical concepts and determinants are more important than others. While testing individual theories (within a specific scientific discipline) can be very informative previous research has shown that the effects of theoretically relevant factors might vanish if other, competing, theoretical factors are taken into account (Liebe et al. 2009). Therefore, theory comparison helps to uncover the key determinants underlying acceptance and protest intentions towards the development of renewable energy sites. Table 1 summarizes the theoretical determinants and their expected effects on acceptance and protest.

Table 1: Overview of theoretical approaches, determinants, and expected effects

Theoretical approach	**Determinants**	**Acceptance**	**Protest**
Attitudes	General attitude of climate change concern	+	–
	Specific attitudes toward renewable energies and natural gas	++	– –
Social norms	Subjective social norm, personal norm	+	–
Not-in-my-backyard	NIMBY beliefs	– –	+ +
Collective action	Conditional cooperation, free riding	–	+/–
Identity	Place attachment	– –	+ +

Note: For theoretical determinants marked by double plus or minus signs, we expect stronger effects.

Attitudes: From a (social-)psychological perspective, attitudes constitute a (or even *the*) key determinant of behavior. Attitudes refer to "[…] a psychological tendency that is expressed by evaluating a particular entity with some degree of favor or disfavor" (Eagly and Chaiken 1993, p. 1). We differentiate between a general attitude of climate change concern and specific attitudes towards renewable energies and natural gas. The general attitude refers to the perception of climate change as a serious problem and the specific attitude to the positive or negative evaluation of each specific type of renewable energy generation. Following the correspondence rule that attitude and behavior should be measured on the same level of specificity (see Hines et al. 1987) *we expect a stronger positive/negative effect of the specific attitudes compared with the general attitude on the acceptance/protest intention regarding the construction of new power plants*.

Johansson and Laike (2007), for example, examine the effect of attitudes and visual perception on intentions to oppose additional local wind turbines and find specific attitudes concerning aesthetics, recreation opportunities, and consequences of wind turbines for the quality of daily life have a negative effect on intentions to oppose the turbines. However, the most important influencing factor is a general evaluation of wind power showing a negative impact, too.

Ansolabehere and Konisky (2009) examine simultaneously opposition to coal, natural gas, nuclear power, and wind power plants in the vicinity of respondents. Attitudes toward these power sources (perceived environmental harm, perceived energy cost and personal risk) have the strongest effect. Demographic, economic, and political factors are also considered in the model. These show smaller and irregular effects.

Social norms: Expectations that prescribe or proscribe certain behavior and that are supported by positive or negative sanctions (i.e., social norms) are an important concept for explaining social order and individual action (Hechter and Opp 2001). Typically, we can distinguish social norms from personal or internalized norms. A social norm is stabilized by a third party that sanctions norm conformity or nonconformity, whereas a personal norm means that an individual sanctions him- or herself. In the context of renewable energy, individuals might receive or expect, for instance, social approval from their family and friends if they support local renewable energy projects. They might also perceive themselves as "environmentalists" and feel a moral obligation to support renewable energy projects and if they do not act in line with this perceived obligation, they have a guilty conscience, and so sanction themselves.

In this paper, we consider both perceived social norms (i.e., subjective norms) as conceptualized in Ajzen's (1991) theory of planned behavior and personal norms viewed as perceived moral obligations (e.g., Schwartz 1977; Schwartz and Howard 1982). The social norm refers to a climate protection norm. Norm content is the extent to which reference group members would like it if an individual supports climate protection measures. A personal norm is feelings of moral obligations toward climate protection. *We expect that perceived positive sanctions (social norms) and moral obligations (personal norms) to support climate protection will increase the acceptance of renewable energy sites and decrease protest intentions.*

Adapting the theory of planned behavior to wind power opposition, Johansson and Laike (2007), for example, cannot find any significant effect of subjective norms on the intention to oppose local wind turbines. Similarly, Read et al. (2013) apply theory of planned behavior to explore intentions to oppose wind farm developments. However, using a hierarchical linear regression, they find in the full model a significant positive effect of subjective norms on the intention to engage in oppositional behavior. Past oppositional behavior also has a significant positive effect.

"Not-in-My-Backyard" Phenomenon: Often the public perceives infrastructure projects as necessary but they strongly oppose these projects in their vicinity. This divergence between general support and local opposition is well known among other researchers on environmental justice (Schively 2007) and is termed the "not-in-my-backyard" (NIMBY) phenomenon: "More formally, NIMBY refers to the protectionist attitudes of and oppositional tactics adopted by community groups facing an unwelcome development in their neighborhood" (Dear 1992, p. 288). Following this simple reasoning, we expect that *NIMBY beliefs and NIMBY attitudes will affect the acceptance of power plants negatively and might turn into higher levels of protest*.

We consider this baseline hypothesis on NIMBY effects and are aware that empirical studies in the context of renewable energy production show that other factors might be much more influential than NIMBY beliefs. For example, in his review, Devine-Wright (2005) gives an overview of factors affecting public perceptions of wind farms including physical, contextual, political and institutional, socio-economic, social and communicative, symbolic and ideological, local, and personal determinants. He also criticizes the "absence of explanatory theoretical frameworks" (p. 136). Wolsink (2007a, 2007b) emphasizes fairness/justice concerns, particularly with respect to distributive and procedural justice. In a nutshell, acceptance increases and protest decreases if citizens are involved in the decision process.

Collective Action: The acceptance of environmental policy measures, particularly if they include negative external effects, can be seen as a contribution to a public (environmental) good for which non-excludability from the benefits applies (Samuelson 1954). This means that even people who have contributed nothing—in our context, those who do *not* accept power plants in their vicinity—benefit from the provision of the good, that is, lower emissions due to the placement of power plants in the vicinity of others. The individual incentive to use the good as a "free rider" leads to a social dilemma, i.e., a situation "in which individual rationality leads to collective irrationality." If everyone acted as a free rider "the public resource would not be provided and we would all be hurt" (Kollock 1998, p. 183). In contrast to a social dilemma and free rider perspective, individuals do make substantial (albeit often suboptimal) contributions to public (environmental) goods (see Ledyard 1995; Camerer 2003for overviews). One explanation for this is that there are different types of individuals in the population—unconditional cooperators, conditional cooperators, and free riders (e.g., Fischbacher et al. 2001; Gächter 2007; Ostrom 2000). Conditionally cooperating individuals only make a contribution to a specific public good when they are convinced that others are also doing so. Conversely, unconditionally cooperating individuals make decisions concerning public goods entirely independent of their expectations of third parties' actions. In the context of renewable energies, conditional cooperation means that individuals only support new sites if they believe others are doing the same. *We expect that conditional cooperation leads to less acceptance of renewable energy sites but we cannot predict whether this also leads to higher protest levels.*

There are only a few studies that directly measure conditional cooperation in surveys on renewable energy acceptance. Ek and Söderholm (2007) find that concerns about conditional cooperation can affect preferences for renewable energy generation in Sweden differently than concerns about unconditional cooperation. Further studies related to environmental issues demonstrate the relevance of conditional cooperation. For example, Liebe et al. (2011) find positive evidence that social dilemma concern can negatively affect willingness to pay for environmental goods. Using experimental designs embedded in population surveys, Bechtel and Scheve (2013) find that conditional cooperation can affect preferences for global climate change agreement, for instance, regarding the number of participating countries and emission levels.

Identity: One of the core concepts of sociological thought is identity (Giddens 1991). In the context of this paper, it refers to individuals' self-definition (compared with social categorizations by others) related to a place. More specifically, the place where people live (and used to live) can be an important part of their self-identity (Gieryn 2000). In this context, the term "place attachment involves positively experienced bonds, sometimes occurring without awareness, that are developed over time from the behavioral, affective, and cognitive ties between individuals and/or groups and their socio-physical environment." (Brown and Perkins 1992, p. 284). Policy measures such as the construction of power plants can alter a landscape and this might cause fear of loss of identity (Devine-Wright 2009) for those who attach meaning to the current landscape. *We therefore expect that a stronger identity with a* *landscape or place attachment has a negative impact on the acceptance of new renewable energy sites and a positive effect on intentions to protest against the construction of these sites.*

Vorkinn and Riese (2001) presented the first empirical study analyzing the effect of place attachment in the context of renewable energies. Using the example of hydro power development in Norway, these authors find place attachment has the strongest explanatory power. The results indicate a negative correlation of place attachment and acceptance. Devine-Wright (2011) explores the effect of place attachment on the acceptance of a tidal energy project at two different sites, finding a significant positive effect of place attachment. In addition, Devine-Wright (2013) examines, among other factors, the effect of place attachment and finds a negative correlation with acceptance of the construction of a new power lines. Read et al. (2013) include a place-related variable in their analysis of intentions to oppose wind farm developments; however, this has no significant effect on intended oppositional behavior. With regard to the acceptance of wind farms, Hall et al. (2013) confirm in a qualitative study the importance of place attachment along with procedural and distributive justice and trust.

2.2 Decomposing public support using Blinder-Oaxaca decomposition

In order to shed more light on the relevance of attitudes for the acceptance of renewable energy expansion, we use Blinder-Oaxaca decomposition (Blinder 1973; Oaxaca 1973) which is used in labor economics to examine wage differentials and how these can be explained by differences in productivity or "discrimination." However, this approach can also be fruitfully applied in other fields (see Jann 2008), as has been shown by Ansolabehere and Konisky (2009) with respect to attitudes toward power plants. Here, endowment effects reflect differences in attribute values that the respondents ascribe to power plants. Discrimination effects mean that, assuming equal attribute values, respondents might weight attributes differently across power plants: "[t]wo power sources might be seen as equally bad for the environment, but individuals might think about the environment when considering one source but not the other" (Ansolabehere and Konisky 2009, p. 568). Characteristics effects refer to differences in the effects of respondents' characteristics on the evaluation of different power plants. Applying decomposition models, we therefore *aim to determine to what extent endowment, discrimination, and characteristics effects are present with respect to acceptance of and protest intentions toward the development of renewable energy sites related to different renewable energy sources*.

Formally, each time two power plants, for example wind power (W) and natural gas (N), are compared regarding the outcome acceptance (A) based on a set of explanatory variables. The main question is how much of the mean outcome difference (*D*) can be explained by group differences in the explanatory variables: $D = E(A_W) – E(A_N)$, where in our example E(.) is the expected value of the outcome "acceptance of new power plants." Following Jann (2008) in a three-fold decomposition the mean outcome difference is divided into three parts: $D = E + C + I$. In our example, *E* refers to group differences between wind power and natural gas regarding explanatory variables such as attitudes (i.e. the endowment effect). What is the expected change in mean acceptance levels for natural gas if it had the predicted values on attitudes regarding wind power? *C* refers to group differences in coefficients regarding attributes of renewables (discrimination effect) and individual characteristics (characteristics effect). What is the expected change in mean acceptance levels for natural gas if it had the coefficients on attitudes regarding wind power? *I* denotes an interaction effect between the endowment and characteristics effect which occur simultaneously. The components of such a decomposition model can be estimated within a least-square regression framework (see Jann 2008 for details).

In their study on acceptance of new power plants, Ansolabehere and Konisky (2009) consider the main effects *E* and *C* described above and investigate attitudes towards coal, natural gas, nuclear power, and wind power, using coal as the reference energy source. Differences in attitudes across power sources are most pronounced in the endowment effect for environmental harm. No endowment effect for perceived energy costs is observed. Discrimination effects are only identified in the comparison of natural gas with coal, and no consistent characteristic effects are evident.

3 Data and variables

The data come from an online survey on renewable energy expansion in Germany that took place in September and October 2013. Participants were members of an access panel whose members were actively recruited by phone (no opt-in panel) and represent the German population that uses the internet at least once a week. We used quota sampling representing the German population regarding gender and age as close as possible. After inspection of the data, 3,192 usable interviews remained (due to missing values and implausible answers) out of 3,400 completed questionnaires. The response rate (standard RR1, American Association for Public Opinion Research (AAPOR) 2016) was 26 percent. Prior to the survey, six focus groups and two pretest surveys were conducted (see appendix A4 for further information about the focus groups).

Table 2 provides an overview of the sample and corresponding values for the German population. In our sample, women are underrepresented and those with higher education and living in mid-sized cities are overrepresented. The mean values for age and income are fairly close to the average values for the German population. While the sample is clearly not representative, it contains sufficient variance on sociodemographics in order to test different theories and to take heterogeneity in population characteristics into account. Since individuals in rural areas are more affected by renewable energy expansion compared to those in urban areas, our data also show considerable variance along the rural-urban continuum.

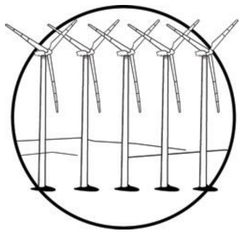
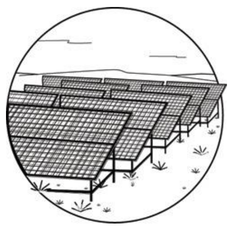
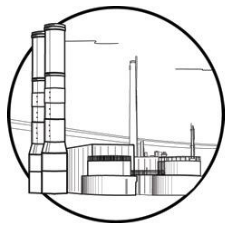
Table 2: Sample description (N=3,192)

Variable	Survey sample (n = 3,192)	German population*
Share of women	45%	51%
Age in years (mean, standard deviation in parentheses)	43 (14)	44
Share of respondents with		
University entrance diploma or higher =1	61%	31%
Household net income in Euro (mean, standard deviation in parentheses)	3,048 (1,519)	3,069
Share of respondents living in…		
Rural areas	31%	23%
Mid-sized cities	33%	42%
Large cities	36%	35%

Note: * Data from Statistisches Bundesamt (2015).

The survey included questions concerning respondents' exposure to renewables, attitudes, acceptance and protest intentions regarding the expansion of renewable energies in Germany. Three renewable energy sources were considered: wind energy, solar energy, and biomass. In addition, natural gas was considered as an alternative energy source. At the beginning of the survey, respondents were shown pictograms and definitions of these renewables (see Table 3). It was also clarified that the survey focused on renewables in the open landscape and did not consider energy production in urban areas, for example, through solar panels on roofs.[1]

Table 3: Definition of renewable energy sources and natural gas as used in the survey

			
Wind energy refers to electricity generation with single wind turbines and wind farms onshore only.	**Solar energy** refers exclusively to the production of electricity with photovoltaic systems in the open landscape, i.e., solar fields.	**Biomass** refers to the production of biogas and its electricity and includes both the biogas plant and the cultivation of the required biomass (such as corn).	**Natural gas** is used for electricity generation in gas-fired power plants. Gas-fired power plants are being built as part of the expansion of renewable energy, to ensure the continuous supply of electricity in Germany.

We did not take into account nuclear energy because Germany decided to stop using this power source. Except for the attitude variables, due to limited survey time, we used a split-sample approach in which, by randomization half of the respondents received the questions regarding the theoretical variables. Tables A1 and A2 in the Appendix provide an overview of the items used to operationalize the theoretical constructs and give corresponding descriptive

[1] In contrast to wind and solar energy the energy source is not unboundedly available in the case of biomass. Therefore, we asked respondents to consider the cultivation of raw material and the power plant when rating the renewable energy biomass. For the most part, biomass is used for electricity generation at the place of production.

figures. When developing the survey items we leaned on the existing literature. The attitudinal items were developed following Ansolabehere and Konisky (2009). Items regarding NIMBY refer to Wolsink (2007b, p. 1202) and those measuring place attachment follow Soini et al. (2012). Our study focuses on the acceptance of new power plants and we asked respondents to assume that this power plant will be constructed within a 10-kilometer radius of their place of residence. We presented this radius to make the scenario more concrete. However, we are aware that this radius could have been larger such as the 20 miles used in Ansolabehere and Konisky (2009) or smaller such as the 8 kilometer in Firestone et al. (2017). In the focus groups carried out prior to our main survey (see appendix A4) it turned out that distances greater than 10 kilometers seem to be problematic in terms of representing “vicinity.” We further assumed that especially for respondents from large cities a 10-kilometer radius is more realistic than a smaller radius. We received no negative feedback on the 10-kilometer radius in the pretest surveys which was designed to check whether respondents have any difficulties with the survey instrument.

4 Results

In this section, we will begin with descriptive results regarding the acceptance of, protest intentions and attitudes toward renewable energy sites and natural gas-fired power plants. Subsequently, we will show the results of multivariate models regarding, first, the comparison of competing theories and, second, Blinder-Oaxaca decomposition.

4.1 Descriptive results

Starting with the acceptance of new power plants in the vicinity of the respondents (i.e., within a 10-kilomter radius of their place of residence), it can be seen in Table 4 that respondents prefer solar fields (89 percent) over wind power facilities (73 percent), followed by biogas plants (50 percent) and natural gas-fired plants (42 percent). The differences between solar and wind power, on the one hand, and biomass and natural gas, on the other hand, are remarkable. Further, there is a clear trend of respondents preferring one of the three renewable energy resources over the non-renewable source. Note that the question order was randomized and therefore, order effects can be ruled out.

Table 4: Descriptive statistics: acceptance (N=3,192)

Electricity generation from…	Wind energy (%)	Solar energy (%)	Biomass (%)	Natural gas (%)
Strongly oppose	7.27	2.29	14.72	15.54
Somewhat oppose	20.08	9.15	34.96	42.58
Somewhat support	46.40	49.06	40.76	35.68
Strongly support	26.25	39.51	9.56	6.20

Note: Response to question "How strongly would you support or oppose the construction of the following renewable power plants and natural gas-fired plant within a 10-kilometer radius of your place of residence?"

Respondents were asked whether they would participate in protest activities (i.e., signing petitions or taking part in demonstrations) opposing the construction of new power plants.

Table 5 shows that the protest potential is rather low. Yet we find a difference between the various types of power plant. The protest potential is highest in the case of natural gas (26 percent would be likely to or certainly would participate), followed by biomass (24 percent), wind power (17 percent), and solar (8 percent).

Table 5: Descriptive statistics: protest (N=3,192)

Electricity generation from…	Wind energy (%)	Solar energy (%)	Biomass (%)	Natural gas (%)
Would certainly not participate	44.74	52.98	31.86	29.70
Would probably not participate	38.47	39.35	43.52	44.14
Would probably participate	10.49	5.33	16.73	18.95
Would certainly participate	6.30	2.35	7.21	7.21

Note: Response to question "How likely would you be to participate in protest activities (e.g., collection of signatures or demonstration) opposing the construction of the following renewable power plants and natural gas-fired plant within a 10-kilometer radius of your place of residence?"

So far, our data suggest a clear trend of people being more in favor of wind and solar energy in their vicinity than biomass or natural-gas fired plants. Additional analyses (presented in the appendix, Table A1) show correlations between acceptance and protest measures within and across different power sources. However, the correlations are mostly small. This indicates that the respondents discriminate between power sources and corresponding survey items on acceptance and protest intentions.

The overall clear pattern regarding wind and solar energy changes somewhat if we take a closer look at different attitudinal dimensions related to the various energy sources (see Table A2 in the appendix). First, indeed there is a clear pattern of solar energy and wind power being perceived as generally a better option than biomass or natural gas. Second, the costs of production (expensive versus cheap) are evaluated quite similar for the four energy sources.

Yet wind and solar energy are perceived as slightly more expensive than biomass and natural gas. Third, energy production from solar and wind energy are seen as less harmful to the environment than biomass and natural gas. The differences in means are striking, up to more than one point on a four-point response scale. Fourth, all four energy sources tend to be perceived as neither detrimental to nor enriching for the landscape.

4.2 Multivariate results

Similar to Ansolabehere and Konisky (2009), Table 6 presents the results of seemingly unrelated regression models (Zellner 1962) which we use to analyze the effects of competing influencing factors on the acceptance and protest intentions regarding each energy source because respondents' answers for each source might not be independent of each other (i.e., residuals in the models are correlated). This is supported by the results of a Breusch-Pagan test of independence (results are reported in the notes under Table 6). Note that all the results presented do not differ substantially if we estimate ordered logit models instead of ordinary least square regression models. For each energy source, the first model shows attitudinal effects for the whole sample and the second model contains the theoretical variables in addition to the attitudes (split-sample).

Acceptance of new power plants in the vicinity

The first models in Table 6 show a clear pattern that the more positively an energy source is evaluated in terms of usefulness (makes sense), environmental effects (harmless), landscape effects (enriching) and costs (cheap), the higher the *acceptance of a new power plant* in a respondent's surroundings. This is the case for both the renewable energy sources and the non-renewable source.

Taking the reduced sample size into account, the second models in Table 6 show that these attitudinal effects are also present if we consider theoretically relevant variables and sociodemographic variables. However, we see differences in the evaluation of energy sources related to the additional variables. Climate change concern has a statistically significant and positive effect on the acceptance of wind power plants and solar fields but not on the acceptance of biogas plants.

The data do not give a clear picture of the other theoretically motivated variables, with the exception of NIMBY beliefs. Respondents who explicitly express that new plants should be built in someone else's vicinity are also more likely to not accept new power plants in their own vicinity. This might appear trivial and tautological at first glance. Yet it has to be stressed that this NIMBY effect is present for *all* three renewable energy sources. The other NIMBY belief (disagreement with the statement: I do not reject new plants generally—after all, it has to be built somewhere) has a statistically significant and negative effect on the acceptance of wind power plants and biogas plants. In addition to the NIMBY effect, we only see a positive and significant effect of the subjective norm in the case of wind power and a negative and significant effect of place identity on the acceptance of solar fields. With regard to the sociodemographic variables, the most notable finding is the tendency for higher educated people to express statistically significant higher acceptance levels towards renewable energy sites but not natural gas. However, for wind power and biomass, this effect is not present in the models that include additional theoretically relevant variables.

Protest intentions towards new power plants in the vicinity

Table 6 also contains the same analyses for *protest intentions*. In the attitudinal models (Model 1 per energy source), we see the relevance of all attitudinal dimensions, except perceived costs. The stronger the perception that using a particular energy source makes sense, harmless to the environment and enriching for the landscape, the lower protest intentions regarding the construction of new power plants in a respondent's surroundings. In addition to these three dimensions, perceived costs (cheap power source) have a statistically significant and negative effect on protest intentions towards natural gas-fired plants.

The extended models including further theory-oriented variables give three main insights. First, NIMBY beliefs have a statistically significant and positive effect on protest intentions. Our results at least suggest that *explicit* NIMBY beliefs are of strong relevance, also when controlling for other important variables. Second, conditional cooperation with respect to climate protection measures (i.e., individuals only being prepared to contribute something if others also do so) have a positive effect on protest towards the construction of wind energy plants and solar fields, that is, the two energy sources associated with climate protection. In other words, unconditional cooperators are less likely to protest and conditional cooperators seem to be more skeptical than unconditional cooperators about others also contributing to solving environmental problems. This skepticism leads to stronger protest intentions. Third, place identity is positively associated with protest motivations. The more a respondent is attached to his or her place of residence, the stronger the intention to protest against new power plants. With respect to the sociodemographic variables, protest intentions tend to be significantly stronger among older respondents and weaker for the higher educated and those living in larger cities compared with those in rural areas.

Decomposition of attitudinal effects

Table 7 presents decomposition models (based on the Stata module provided by Jann 2008) analyzing the components of differences in attitudinal effects across power plants, namely, endowments, discrimination, and individual characteristics effects. We estimated decomposition models comparing pairwise power plants regarding both acceptance and protest. These models include the same variables than the ones presented in Model 1 in table 6. In order to illustrate differences in attitudinal effects, in Table 7 we only report main effects and do not present interaction effects between endowment and discrimination effects (in all models at least one interaction effect is statistically significant at the 5% level, most often two effects). Overall, the endowment effect accounts for the largest differences in all pairwise comparisons. This holds true in particular for the attitudinal dimension "makes sense," and so with respect to the comparison of wind energy versus natural gas and biomass as well as solar energy versus natural gas and biomass. Differences amount to values greater than 0.3 for the acceptance of new power plants and equal or greater than 0.2 for protest intentions. However, the endowment effect related to the extent to which it is perceived to make sense overall is less relevant for the comparison of wind energy and solar energy with natural gas and biomass, respectively.

The other attitudinal dimensions—environmental harmfulness, costs, and landscape effects—are also statistically significant components in explaining differences in the acceptance of and protest intentions toward new power plants. With respect to these dimension, Table 7 shows that environmental effects and landscape effects account for the largest differences in acceptance of and protest against new power plants. The corresponding effects are statistically significant across most pairwise comparisons whereas the cost dimension is less relevant across comparisons. Again, generally, differences are much more pronounced in comparing wind and solar energy with natural gas and biomass, respectively.

We also find indications of discrimination effects. They are relevant in all comparisons and are particularly pronounced for perceived landscape effects, irrespective of whether respondents perceive an energy plant as something that harms or enriches the landscape. This means respondents give different weights to the landscape dimension when comparing power plants. Two power plants might be perceived as equally detrimental but this perception might be activated only regarding one of the plants and then this gains behavioral relevance. In addition, considerable discrimination effects regarding the perceived environmental effects of energy sources are present in the comparison of wind energy versus natural gas, solar energy versus natural gas, and biomass versus natural gas. They are much weaker (10 percent significance level) for comparisons of wind energy and biomass as well as solar energy and biomass.

Table 7 also indicates few characteristic effects. These are, however, weaker overall than the endowment and discrimination effects. We find, for example, characteristic effects with respect to age and education. For both variables, evaluations of wind power versus natural gas and solar energy versus natural gas differ.

Taken together, in terms of effect size and statistical significance endowment effects—differences in the evaluation of single power plants—explain most of the differences in any comparison presented in Table 7. Exceptions are the comparisons of solar energy versus wind power and biomass versus natural gas. In both cases, endowment effects and discrimination (/characteristics) effects are equally relevant or one of the effects slightly outweighs the other (for instance, in the comparison of solar energy versus wind energy).

Table 6: Seemingly unrelated regression: coefficients and z-values of the determinants of acceptance of and protest against renewable power plants in brackets

	Acceptance						
	Wind energy		Solar energy		Biomass		Natural gas#
	Model 1: Attitudes	Model 2: +Theories	Model 1: Attitudes	Model 2: +Theories	Model 1: Attitudes	Model 2: +Theories	Model 1: Attitudes
Climate change		0.0413* (1.98)		0.0707*** (3.79)		0.0242 (1.23)	
Harmful/ harmless	0.114*** (6.63)	0.0940*** (3.96)	0.133*** (8.54)	0.128*** (5.97)	0.175*** (11.39)	0.182*** (8.44)	0.233*** (13.59)
Detrimental/ enriching	0.394*** (26.80)	0.348*** (17.30)	0.292*** (22.42)	0.268*** (15.51)	0.324*** (19.62)	0.302*** (13.10)	0.245*** (15.67)
Costly/cheap	0.0679*** (4.59)	0.0582** (2.94)	0.0660*** (5.32)	0.0547*** (3.34)	0.0654*** (4.58)	0.0605** (3.06)	0.0295* (2.20)
Doesn't make sense /makes sense	0.461*** (25.44)	0.419*** (15.87)	0.400*** (25.73)	0.334*** (14.80)	0.466*** (33.24)	0.463*** (23.26)	0.440*** (29.06)
Subjective social norm		0.0484* (2.26)		0.0196 (1.03)		0.0129 (0.64)	
Personal norm		0.0275 (1.12)		0.0340 (1.56)		0.0123 (0.53)	
NIMBY1		-0.115*** (-4.99)		-0.0457* (-2.24)		-0.100*** (-4.65)	
NIMBY2		-0.0941*** (-3.77)		-0.0338 (-1.54)		-0.0533* (-2.29)	
Conditional cooperation		0.00609 (0.27)		0.0108 (0.53)		0.0134 (0.62)	
Free riding		0.0107 (0.37)		-0.0166 (-0.63)		-0.0230 (-0.83)	
Place identity		-0.0139 (-1.96)		-0.0128* (-2.02)		-0.00500 (-0.74)	
Female	-0.0479* (-2.14)	-0.0649* (-2.09)	-0.0242 (-1.21)	-0.0527 (-1.91)	-0.0827*** (-4.05)	-0.0656* (-2.25)	-0.0862*** (-4.01)

Age	0.000378	0.000826	0.000479	0.00104	-0.000222	-0.000154	0.00312***
	(0.46)	(0.71)	(0.65)	(1.01)	(-0.30)	(-0.14)	(3.91)
Education (Abitur+=1)	0.0669**	0.0582	0.0585**	0.0669*	0.0745***	0.0283	-0.0429
	(2.87)	(1.80)	(2.80)	(2.31)	(3.48)	(0.92)	(-1.90)
Income	-0.0000270*	-0.0000456**	-0.0000181	-0.0000388*	-0.00000447	0.00000114	0.0000120
	(-2.18)	(-2.62)	(-1.64)	(-2.49)	(-0.39)	(0.07)	(1.01)
City	0.0222	-0.0230	0.0508*	0.0237	0.00237	-0.0369	0.0868***
	(0.81)	(-0.61)	(2.08)	(0.70)	(0.09)	(-1.03)	(3.31)
Small town	0.0252	-0.0179	0.0558*	0.0169	-0.00345	-0.0233	0.0463
	(0.91)	(-0.47)	(2.26)	(0.50)	(-0.14)	(-0.65)	(1.75)
Intercept	-0.0406	0.554**	0.483***	0.838***	-0.0671	0.215	-0.106
	(-0.52)	(3.16)	(6.77)	(5.39)	(-1.06)	(1.41)	(-1.67)
N	3192	1603	3192	1603	3192	1603	3192
R^2	0.49	0.51	0.40	0.39	0.56	0.57	0.59

Protest intentions

	Wind energy		Solar energy		Biomass		Natural Gas#
	Model 1: Attitudes	Model 2: +Theories	Model 1: Attitudes	Model 2: +Theories	Model 1: Attitudes	Model 2: +Theories	Model 1: Attitudes
Climate change		0.0264		0.00872		0.0331	
		(1.03)		(0.40)		(1.22)	
Harmful/ harmless	-0.0752***	-0.0258	-0.0787***	-0.0709***	-0.129***	-0.108***	-0.171***
	(-4.45)	(-1.11)	(-5.19)	(-3.40)	(-7.41)	(-4.11)	(-8.81)
Detrimental/ enriching	-0.216***	-0.188***	-0.143***	-0.123***	-0.262***	-0.249***	-0.188***
	(-14.82)	(-9.48)	(-11.22)	(-7.25)	(-13.98)	(-8.85)	(-10.61)
Costly/cheap	-0.0164	-0.0190	0.0164	0.0144	-0.0212	0.00459	-0.0397**
	(-1.13)	(-0.98)	(1.36)	(0.91)	(-1.31)	(0.19)	(-2.62)
Doesn't make sense/makes sense	-0.316***	-0.247***	-0.224***	-0.171***	-0.261***	-0.289***	-0.304***
	(-17.60)	(-9.48)	(-14.72)	(-7.77)	(-16.45)	(-11.91)	(-17.79)
Subjective social norm		-0.00447		0.0118		0.0867**	
		(-0.17)		(0.52)		(3.13)	
Personal norm		0.00898		-0.00246		0.0306	
		(0.30)		(-0.10)		(0.97)	

NIMBY1		0.256***		0.208***		0.229***	
		(9.09)		(8.65)		(7.76)	
NIMBY2		0.138***		0.0886***		0.0801*	
		(4.53)		(3.42)		(2.50)	
Conditional cooperation		0.0581*		0.0552*		0.00686	
		(2.07)		(2.29)		(0.23)	
Free riding		-0.00133		0.0232		0.0514	
		(-0.04)		(0.75)		(1.35)	
Place identity		0.0335***		0.0238**		0.0240**	
		(3.84)		(3.18)		(2.60)	
Female	-0.0213	-0.0213	0.0131	0.000310	-0.0413	-0.111**	0.0409
	(-0.78)	(-0.56)	(0.55)	(0.01)	(-1.49)	(-2.77)	(1.43)
Age	0.00412***	0.00405**	0.00245**	0.00290*	0.00659***	0.00515***	0.00269*
	(4.11)	(2.84)	(2.85)	(2.40)	(6.50)	(3.45)	(2.53)
Education (Abi+=1)	-0.0851**	0.00388	-0.106***	-0.0519	-0.0622*	-0.00152	-0.0404
	(-2.98)	(0.10)	(-4.31)	(-1.52)	(-2.14)	(-0.04)	(-1.34)
Income	-0.00000692	-0.00000996	-0.0000344**	-0.0000258	-0.0000449**	-0.0000259	-0.0000393*
	(-0.46)	(-0.47)	(-2.65)	(-1.41)	(-2.92)	(-1.15)	(-2.47)
City	-0.174***	-0.106*	-0.104***	-0.0994*	-0.132***	-0.0918	-0.169***
	(-5.20)	(-2.28)	(-3.62)	(-2.50)	(-3.85)	(-1.87)	(-4.81)
Small town	-0.117***	-0.0766	-0.0619*	-0.0411	-0.0360	-0.0211	-0.107**
	(-3.47)	(-1.64)	(-2.13)	(-1.03)	(-1.05)	(-0.43)	(-3.03)
Intercept	3.615***	1.813***	3.017***	1.734***	3.556***	2.122***	3.798***
	(43.00)	(8.87)	(40.41)	(9.91)	(45.65)	(10.28)	(48.58)
N	3192	1603	3192	1603	3192	1603	3192
R^2	0.24	0.29	0.13	0.21	0.25	0.28	0.18

Note: z-values in parentheses. $^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Seemingly unrelated regressions were estimated for Model 1 and Model 2, respectively. Each comprises eight regressions, i.e. acceptance and protest of all four energy sources. Breusch-Pagan test of independence for Model 1: χ^2= 5831.01; p < .000; Breusch-Pagan test of independence for Model 2, χ^2= 1631.53; p < .000. # Natural gas is used as a comparison category.

Table 7: Results of decomposition models for acceptance and protest intentions, n= 6,384

		Acceptance			**Protest**	
Variable	Endowment effect	Discrimination effect	Characteristics effect	Endowment effect	Discrimination effect	Characteristics effect
Wind compared to natural gas						
Harmful/harmless	0.256***	-0.224***		-0.174***	0.0670	
	(11.61)	(-3.85)		(-6.16)	(0.89)	
Detrimental/enriching	-0.0250***	0.313***		0.0161***	-0.107	
	(-5.09)	(5.98)		(4.21)	(-1.62)	
Costly/cheap	-0.00335*	0.0626		0.00538*	0.124+	
	(-2.27)	(1.17)		(2.48)	(1.80)	
Doesn't make sense/makes sense	0.326***	0.0998		-0.219***	-0.192*	
	(21.51)	(1.52)		(-11.98)	(-2.17)	
Female			0.0186			-0.0310*
			(1.38)			(-2.19)
Age			-0.136**			0.0846+
			(-2.82)			(1.72)
Education			0.0678***			-0.0312
			(3.50)			(-1.54)
Income			-0.0792*			0.0648+
			(-2.36)			(1.92)
City			-0.0236+			-0.00231
			(-1.75)			(-0.17)
Small town			-0.00700			-0.00339
			(-0.56)			(-0.26)
Intercept		0.0491			0.165	
		(0.50)			(1.26)	
Solar compared to natural gas		**Acceptance**			**Protest**	
	Endowment effect	Discrimination effect	Characteristics effect	Endowment effect	Discrimination effect	Characteristics effect
Harmful/harmless	0.291***	-0.213***		-0.198***	0.0735	
	(11.67)	(-3.65)		(-6.17)	(1.04)	
Detrimental/enriching	0.0500***	0.0835+		-0.0321***	0.0899	
	(9.14)	(1.72)		(-5.79)	(1.49)	
Costly/cheap	-0.00533*	0.0416		0.00856**	0.208**	
	(-2.52)	(0.85)		(2.81)	(3.27)	

Doesn’t make sense/makes sense	0.359***	-0.0966		-0.241***	0.135	
	(22.14)	(-1.48)		(-12.09)	(1.63)	
Female			0.0290*			-0.0117
			(2.33)			(-0.86)
Age			-0.124**			0.0284
			(-2.73)			(0.61)
Education			0.0606***			-0.0431*
			(3.43)			(-2.22)
Income			-0.0618*			0.00839
			(-2.04)			(0.27)
City			-0.0125			0.0235+
			(-1.02)			(1.81)
Small town			0.00369			0.0151
			(0.32)			(1.20)
Intercept		0.678***			-0.614***	
		(6.72)			(-4.59)	
Biomass compared to natural gas					**Protest**	
	Endowment effect	Discrimination effect	Characteristics effect	Endowment effect	Discrimination effect	Characteristics effect
Harmful/harmless	0.0787***	-0.130*		-0.0535***	0.0255	
	(10.09)	(-2.44)		(-5.90)	(0.37)	
Detrimental/enriching	-0.0348***	0.179***		0.0224***	-0.233***	
	(-8.02)	(3.33)		(5.47)	(-3.36)	
Costly/cheap	-0.000660	0.0686		0.00106	0.109	
	(-0.82)	(1.32)		(0.83)	(1.52)	
Doesn’t make sense/makes sense	0.0115	0.104+		-0.00772	0.0440	
	(1.34)	(1.84)		(-1.34)	(0.58)	
Female			0.000406			-0.0359**
			(0.03)			(-2.86)
Age			-0.156***			0.192***
			(-3.58)			(4.23)
Education			0.0730***			-0.0174
			(4.24)			(-0.97)
Income			-0.0320			-0.0121
			(-1.12)			(-0.40)
City			-0.0296*			0.0137
			(-2.49)			(1.11)
Small town			-0.0160			0.0236*

			(-1.41)			(2.00)
Intercept		0.0418			-0.120	
		(0.51)			(-1.09)	
Solar compared to wind		**Acceptance**			**Protest**	
	Endowment effect	Discrimination effect	Characteristics effect	Endowment effect	Discrimination effect	Characteristics effect
Harmful/harmless	0.0192***	0.0168		-0.0191***	0.00991	
	(5.71)	(0.21)		(-4.76)	(0.11)	
Detrimental/enriching	0.119***	-0.219***		-0.0632***	0.187***	
	(15.46)	(-5.03)		(-8.91)	(3.97)	
Costly/cheap	-0.00324*	-0.0203		0.000697	0.0819	
	(-2.51)	(-0.44)		(0.72)	(1.63)	
Doesn’t make sense/Makes sense	0.0356***	-0.253**		-0.0276***	0.421***	
	(5.78)	(-2.95)		(-5.50)	(4.52)	
Female			0.0103			0.0193+
			(0.89)			(1.86)
Age			0.0123			-0.0562
			(0.29)			(-1.49)
Education			-0.00720			-0.0119
			(-0.44)			(-0.79)
Income			0.0175			-0.0564*
			(0.61)			(-2.29)
City			0.0111			0.0258*
			(0.94)			(2.46)
Small town			0.0107			0.0185+
			(0.99)			(1.92)
Intercept		0.629***			-0.779***	
		(6.02)			(-6.43)	
Wind compared to biomass		**Acceptance**			**Protest**	
	Endowment effect	Discrimination effect	Characteristics effect	Endowment effect	Discrimination effect	Characteristics effect
Harmful/harmless	0.131***	-0.109+		-0.111***	0.0481	
	(9.97)	(-1.79)		(-6.13)	(0.61)	
Detrimental/enriching	0.0131*	0.126*		-0.0106*	0.118+	
	(2.34)	(2.49)		(-2.31)	(1.83)	
Costly/cheap	-0.00456**	-0.00591		0.00135	0.0147	
	(-2.85)	(-0.11)		(0.90)	(0.22)	
Doesn’t make sense/makes sense	0.343***	-0.00380		-0.199***	-0.238**	

	Acceptance			Protest		
	(23.44)	(-0.06)		(-11.70)	(-2.83)	
Female			0.0182			0.00486
			(1.44)			(0.36)
Age			0.0194			-0.107*
			(0.43)			(-2.24)
Education			-0.00527			-0.0138
			(-0.29)			(-0.72)
Income			-0.0473			0.0768*
			(-1.49)			(2.37)
City			0.00600			-0.0160
			(0.47)			(-1.19)
Small town			0.00902			-0.0270*
			(0.76)			(-2.17)
Intercept		0.00731			0.286*	
		(0.07)			(2.18)	

Solar compared to biomass		**Acceptance**			**Protest**	
	Endowment effect	Discrimination effect	Characteristics effect	Endowment effect	Discrimination effect	Characteristics effect
Harmful/harmless	0.157***	-0.0962		-0.133***	0.0556	
	(10.06)	(-1.57)		(-6.16)	(0.75)	
Detrimental/enriching	0.113***	-0.0894+		-0.0916***	0.302***	
	(13.42)	(-1.88)		(-9.27)	(5.11)	
Costly/cheap	-0.00791***	-0.0268		0.00235	0.0989	
	(-3.57)	(-0.55)		(0.92)	(1.61)	
Doesn't make sense/makes sense	0.379***	-0.202**		-0.220***	0.0917	
	(24.39)	(-3.04)		(-11.81)	(1.16)	
Female			0.0286*			0.0242+
			(2.41)			(1.86)
Age			0.0317			-0.163***
			(0.74)			(-3.40)
Education			-0.0125			-0.0257
			(-0.72)			(-1.35)
Income			-0.0298			0.0204
			(-1.04)			(0.67)
City			0.0171			0.00985
			(1.45)			(0.75)
Small town			0.0197+			-0.00843

		(1.79)		(-0.70)
Intercept	0.636***		-0.494***	
	(6.22)		(-3.86)	

Note: z-values in parentheses. + $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. All models also include interactions effects between endowment and discrimination effects. These interaction effects are not displayed in the table.

5 Discussion and conclusions

Many countries are committed to an increase in renewable energy production, including the construction of new power plants. Yet renewable energies also entail negative external effects, and these effects may lead to lower acceptance levels and protest behavior. In Germany, the general public expresses strong support for renewable energy expansion and strong opposition to conventional energy production, especially nuclear power. Somewhat in contrast to this general support are local protests against new power plants. Yet the scope of these protests might be overestimated. For example, McAdam and Boudet (2012) show in a comparative study for communities facing environmentally risky projects in the US that the level of actual protests and their impact on decision making is rather low and weak when taking all communities with and without protests occurring into account. It seems that research tends to look at communities with protest activities, ignoring the non-protesting ones, and this can create a bias. However, while protest activities and their impact should not be overestimated, the prevalence of protest activities, particularly given the ambitious goals of German environmental policy, is real and relevant.

Against this background, we studied the acceptance of and intentions to protest against the construction of new renewable energy power plants in Germany. First, in line with previous research (e.g., Engels et al. 2013), we find that German respondents are generally more prepared to accept and less likely to actively protest against solar energy and wind energy, compared with biomass and natural gas. While the degree of urbanization (rural areas, mid-sized cities, large cities) does not play a role in acceptance (contrary to e.g. a study on wind power by Langer et al. 2018), it has a negative effect on protest intentions, especially in large cities. This might reflect the fact that in rural areas power plants are more visible on a daily basis than in cities. Therefore, on average, respondents in cities might perceive that they are less exposed to energy sites and perceive less need for protesting against new sites .

Second, we analyzed competing theories to explain acceptance and protest. In Table 8, we present a summary of our main findings, that is, whether our theoretical hypotheses are supported empirically. We find strong effects of specific attitudes on both acceptance and protest. Our results also support NIMBY beliefs which lead to lower acceptance levels and stronger protest intentions. This finding is important because the literature tends to be unsupportive of NIMBY explanations related to renewable energy sites (e.g., Wolsink 2000).

However, compared to other studies we do not measure NIMBY via the distance between renewable energy sites and individuals' homes (e.g., Larson and Krannich 2016) but by directly surveying NIMBY beliefs. While these beliefs have an effect on acceptance and protest intentions they are only hold by a minority in our sample (this corresponds for example with findings by Swofford and Slattery 2010 regarding a wind farm facility in Texas, USA). In addition, attitude toward climate change affects acceptance but not protest and it is only relevant for wind and solar energy but not for biomass (e.g. Swofford and Slattery 2010 found a relationship between climate change attitudes and support of wind energy in a community in Texas, USA). This suggests that wind and solar energy are perceived as more important in solving climate change problems compared with biomass. Further, wind turbines and solar panels are more prominent features in the landscape, as they are either highly visible or cover large areas and are therefore possibly more present. The hypotheses regarding conditional cooperation and place identity are supported for protest intentions only. The relevance of conditional cooperation is in line with previous (Ek and Söderholm 2007; Liebe et al. 2011). Yet, it has to be stressed that there are only a few studies testing conditional cooperation in the context of renewable energy production. The finding on place identity is in contrast to Read et al. (2013) who did not find a significant effect of place identity on intentions to oppose wind farm developments. Further, we fail to support previous studies that found a significant and negative relationship between place identity and acceptance of renewable energy developments (e.g., Vorkinn and Riese 2001; Devine-Wright 2013). This should be followed up in future research.

In line with the correspondence rule (Ajzen and Fishbein 1977), we find stronger effects for specific constructs. Yet this comes at the cost of a lower theoretical explanatory power which would be higher if we used general concepts that are able to explain different forms of behavior. One example in our study is the general attitude toward climate change which can be used to explain acceptance of renewable energy but also many forms of individual environmental behavior such as energy saving.

As well as attitudes and NIMBY beliefs, our study shows the relevance of two theoretical concepts—collective action/conditional cooperation and identity/place attachment—which are often neglected in large-scale environmental research. These concepts proved to be more relevant than (subjective) social norms, a common concept in sociology. With regard to theory development, our study suggests that further efforts should be directed towards comparing theories on empirical grounds with applications on different behavioral outcomes such as acceptance and protest. A critical mass of studies will reveal which theoretical factors are more relevant than other factors and to which extent their relevance depends on energy sources, country contexts, etc. Yet, also theories themselves have to be critically evaluated, for example regarding theoretical coverage (i.e. the number of phenomena that can be explained by specific explanatory factors).

Table 8: Overview of results (grey shading means the hypothesis is supported by the data)

Theoretical Approach	Determinants	Acceptance	Protest
Attitudes	General attitudes: climate change concern	+	–
	Specific attitudes: attitudes towards renewable energies and natural gas	++	– –
Social norms	Subjective social norm, personal norm	+	–
Not-in-my-backyard	NIMBY beliefs; current exposure to power plants	– –	+ +
Collective action	Conditional cooperation, free riding	–	+/–
Identity	Sense of place	– –	+ +

Third, going beyond “simple” attitude behavior relations, we analyzed to what extent differences in the evaluation of new power plants can be attributed to endowment effects regarding attitudinal dimensions, discrimination effects regarding the relative weight of attitudinal dimensions, and characteristics effects regarding respondents’ sociodemographic context, for instance. Based on decomposition models, frequently used in labor-market research, we see, for example, that most of the differences can be explained by endowment effects; power sources are evaluated differently along several attitudinal dimensions such as cost and environmental harmfulness. Endowments were, however, less relevant for comparing wind and solar energy as well as for comparing natural gas and biomass. One explanation might be that these energy sources (wind/solar and natural gas/biomass) are *perceived* as being more similar to each other, although they are in fact very different. Also, strong discrimination effects are present in the data. These show that, given the same evaluation on the attitudinal dimensions of two power sources, respondents tend to give different weights to these dimensions in their decisions on acceptance and intended participation in protests.

Similar to the study by Ansolabehere and Konisky (2009), our findings demonstrate the fruitfulness of using decomposition models in the context of attitudinal research.

Our study has limitations which have to be discussed. First, compared with the general public, our sample includes a higher proportion of highly educated individuals. Higher educated people may, due to better level of knowledge, have a higher concern for the environment which may lead to higher acceptance of renewable energy sites. Our multivariate analyses seem to support this supposition. Since we are interested in the relative effects of competing theoretical variables and attitudinal components and we control for sociodemographic variables, the sample bias towards higher educated respondents is not a major issue for this study.

Second, we examined behavioral intentions and not behavior itself. It is well known that there is a hypothetical bias, mostly in the direction that not all intentions expressed by respondents translate into actual behavior. Further, study results might differ if respondents are actually exposed to renewable energy developments (e.g., Zoellner et al. 2008; Swofford and Slattery 2010). Such differences cannot be ruled out. However, as has been shown above, our results are in line with other studies from Germany and other countries. This supports to some extent the validity of our results, which also holds true for the timeliness of our findings (e.g. Sonnberger and Ruddat 2018) taking into account that we collected data in 2013 and attitudes towards renewables might have changed since then. Moreover, if renewable expansion is perceived as socially desirable, we might overestimate acceptance and underestimate protest intentions. Yet if the hypothetical bias and social desirability bias is distributed equally over different sociodemographic groups in the survey, relative differences between groups still remain and provide valuable insights.

Third, some of the theoretical concepts were only measured with a single item (e.g., norms and conditional cooperation). More complex measurement instruments would do more justice to the corresponding complex theoretical arguments. Yet, when we compare theories empirically, there is a clear trade-off between complexity and the possibility of considering more than two theories in a survey. Further, for some concepts, single-item measurements (e.g., for subjective norms) are often used in the literature (e.g., Liebe et al. 2011) and they can be considered to be standard. Fourth, while we compared many different theoretical approaches, we could not consider all. For example, previous studies have shown the relevance of fairness concerns – distributive and participatory justice – in the context of renewable energy projects (e.g., Zoellner et al. 2008; Liebe et al. 2017; Langer et al. 2018 for the acceptance of wind energy). Fairness concerns might be one driving factor for NIMBY behavior and because we did not consider them, we were not able to study whether fairness would rule out the reported NIMBY effects.

In summary, the present study shows that although there is strong general support for renewable energy production, the evaluation of specific power sources differs considerably. Further, given the same general preference for two power sources, specific attitudinal dimensions such as landscape effects might be weighted more heavily in the valuation of one source compared to another. This carries an important message for political decision-making: the specific type of renewable energy and corresponding attitudinal dimensions matter when it comes to the acceptance of new power plants. Political campaigning can help to provide the general public with information on the "true" costs and benefits of different energy sources and so provide tailor-made information. This might alter attitudes and, in turn, acceptance and protest motivations. References to climate change might only pay off in terms of mobilizing support for wind and solar energy but not biomass. At least in our survey, respondents do not associate biomasss with climate protection. Regarding potential protests towards new power plants, people's place attachment and corresponding identity has to be taken into account. Those who are strongly attached to their place of residence are more likely to protest against landscape changes (yet attachments at the national and global level might also be important, see Devine-Wright and Batel 2017). It might therefore be important to give them a voice in the planning process of new power plants, showing that their concerns are taken seriously. Such conclusions could only be obtained because this study used a strategy of comparing different theoretical concepts and of decomposing different effects of attitudes on acceptance and protest intentions. This approach proved fruitful and should be taken up again in future research.

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Appendix

Table A1: Pairwise correlations between acceptance and protest intentions regarding each power source

	Acceptance: Wind energy	Acceptance: Solar energy	Acceptance: Biomass	Acceptance: Natural gas	Protest: Wind energy	Protest: Solar energy	Protest: Biomass
Acceptance: Solar energy	0.282***						
Acceptance: Biomass	0.034^{+}	0.0591**					
Acceptance: Natural gas	-0.143***	-0.057**	0.092***				
Protest: Wind energy	-0.548***	-0.158***	-0.035*	0.119***			
Protest: Solar energy	-0.212***	-0.394***	-0.030^{+}	0.072***	0.598***		
Protest: Biomass	-0.067***	-0.042*	-0.527***	-0.0004	0.379***	0.342***	
Protest: Natural gas	0.027	0.015	-0.083***	-0.475***	0.270***	0.287***	0.433***

Note: $^{+}$ $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table A2: Summary of independent variables

Question wording	Variables	Mean	S.D.
Model 1 (N= 3,192)			
How costly or cheap do you think it is to produce electricity with each of the following renewable energies or rather natural gas? (1= very costly; 2= rather costly; 3= rather cheap; 4= very cheap)	Costly/cheap wind	2.396	0.760
	Costly/cheap solar	2.346	0.825
	Costly/cheap biomass	2.463	0.722
	Costly/cheap natural gas	2.48	0.812
How harmful or harmless to the environment do you think each of the following power sources is? (1= very harmful; 2= rather harmful; 3= rather harmless; 4= completely harmless)	Harmful/harmless wind	3.24	0.704
	Harmful/harmless solar	3.391	0.669
	Harmful/harmless biomass	2.476	0.788
	Harmful/harmless natural gas	2.171	0.707
How enriching or detrimental for the landscape do you think it is to produce electricity with each of the following renewable energies or rather natural gas? (1= very enriching; 2= rather enriching; 3= rather detrimental; 4= extremely detrimental)[a]	Detrimental/enriching wind	2.171	0.826
	Detrimental/enriching solar	2.492	0.78
	Detrimental/enriching biomass	2.129	0.655
	Detrimental/enriching natural gas	2.278	0.716
All in all: To what extent do you think it makes sense to produce electricity with each of the following renewable energies or rather natural gas? (1= makes a lot of sense; 2= makes sense; 3= doesn't make much sense; 4= doesn't make sense at all)[a]	Doesn't make sense/makes sense to use wind energy	3.412	0.711
	Doesn't make sense/makes sense to use solar energy	3.488	0.698
	Doesn't make sense/makes senseful to use biomass	2.673	0.891
	Doesn't make sense/makes sense to natural gas	2.646	0.795
Model 2 (N= 1,603)			
If we continue our way of life, we are approaching a climate catastrophe.[b]	Climate change concern	3.183	0.836
Persons who are important to me would be in favor of me contributing to climate protection.[b]	Subjective norm	2.850	0.812
For me, it is a moral obligation to contribute to climate change. [b]	Personal norm	3.087	0.801
New plants should be built in someone else's vicinity—not next to me![b]	NIMBY 1	1.801	0.727
I do not reject new plants generally—after all, they have to be built somewhere![b, a]	NIMBY 2	1.701	0.666
If others do not take part, I do not accept abstaining from something.[b]	Conditional cooperation	1.748	0.792

Since there are others who do enough for climate protection, I do not have to contribute.[b]	Free-riding	1.454	0.621
I like to be in the landscape next to my place of residence.[b, c]	Place identity 1	1.455	0.615
Often, I spend my free time in the countryside next to my place of residence.[b, c]	Place identity 2	1.703	0.761
The landscape around my place of residence is a part of mine.[b, c]	Place identity 3	1.87	0.837
It is very important to me that the landscape around my place of residence does not change.[b, c]	Place identity 4	1.87	0.711

Notes:

[a] Reverse-scored items are used for the analysis

[b] Measured on a 4-point scale *from* 1= strongly agree *to* 4= strongly disagree

[c] On the basis of the results of a factor analysis, all items are aggregated in the sum index 'Place identity' *from* 1= weak place identity *to* 16 strong place identity

Table A3: Place identity: factor loadings and Cronbach's alpha (N= 1,603)

Item	Factor loading
I like to be in the landscape next to my place of residence.	0.7686
Often, I spend my free time in the landscape next to my place of residence.	0.7689
The landscape around my place of residence is a part of mine.	0.6628
It is very important to me that the landscape around my place of residence does not change.	0.4327
Cronbach's alpha	0.7714

A4. Further information regarding focus group discussion

Prior to the survey, we conducted six focus groups in smaller and medium-sized German cities (Bad Kissingen, Goslar, Nauen, Paderborn, Rotenburg / Wümme, Stendal) in autumn 2012. We chose the locations in order to cover regions which are affected by the renewables solar energy, wind energy and biomass in a varying extent. Between seven and ten individuals participated in each focus group. The participants were recruited by a survey organization taking gender, age, and educational background as criteria into account. We conducted the focus groups based on a structured discussion regarding renewables (what participants associate with renewables; their acceptance of renewable energy projects in their vicinity; etc.). In the last part of the focus groups we presented some parts of the questionnaire intended to use in the main survey and asked participants to answer and discuss the questions. Taken together, respondents revealed a generally positive attitude towards renewables. However, the predominant renewable energy source in the respective region was clearly reflected in the discussions, and participants expressed more critical comments regarding the energy sources they are exposed to. In an open discussion, participants emphasized, next to positive aspects, mainly disadvantages of renewables, e.g., regarding negative effects on landscape and animals, competition to food production, and subsidies. By reflecting on the survey questions, it turned out that distances between energy sites and individuals' homes which are greater than 10 kilometers seemed rather unrealistic in terms of "vicinity," i.e. participants would not perceive such distances as being close to their homes.