

# Designing local renewable energy communities to increase social acceptance: Evidence from a choice experiment in Austria, Germany, Italy, and Switzerland

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## Abstract

Low social acceptance to new energy infrastructure may hinder achieving the European Union's goal that 32% of energy consumption come from renewable sources. A vast literature is available on the social acceptance of specific renewable energy technologies, but existing research lacks assessments regarding comprehensive transformations to local energy systems. Moreover, the promising energy storage technology power-to-gas has not yet been addressed in acceptance studies. This paper fills these gaps in the acceptance literature by analysing data from a choice experiment survey with 2,000 respondents across four nations (Germany, Austria, Italy, and Switzerland). Results from the analysis show that solar farms and power-to-gas infrastructure increase acceptance of local energy communities, while wind farms have an ambiguous effect, and gas power plants and power lines decrease acceptance. The derived willingness to pay estimates can be used by energy policymakers to ensure acceptable price changes accompany local energy system changes. Additionally, we investigate whether stated support from political opinion leaders at the local, national, and EU levels can increase the acceptance of renewable energy systems. Results suggest that Italian choices are influenced by the opinions of EU and national governmental bodies, and that Swiss choices are sensitive to the opinions of local politicians.

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## 1 Introduction

European countries are committed to increasing renewable energy production to at least 32% of the share of energy consumed in the EU by 2030 and 20% by 2020 (European Commission, 2018, 2009). The increase of renewable energy production by about 66% between 2006 and 2016 (Eurostat, 2018) reflects the political consensus of this ambition, while also demonstrating strong private support for such policies. However, at the same time resistance to certain renewable energy projects, like wind parks or hydropower plants, has turned out to be a major issue for further developments. In addition, renewable electricity production from intermittent sources requires supportive infrastructure, such as storage technologies or back-up generation; technologies that are also confronted with limited public acceptance (Cohen et al., 2016a; Friedl & Reichl, 2016, Cohen et al. 2014; Devine-Wright, 2008; Devine-Wright, 2005;). Moreover, even when general public opinion polls are positive, strong local opposition may occur when it comes to the realization of nearby projects (Liebe & Dobers, 2019).

No striking solution to the challenge of public acceptance has evolved so far, but promising approaches are emerging. One of these approaches are participatory local energy communities, which the European Commission has identified as having positive benefits for acceptance of the energy transition: “*Local citizen participation in renewable energy projects through renewable energy communities has resulted in substantial added value in terms of local acceptance of renewable energy [...]*” (European Commission, 2018). Renewable energy communities are characterised by groups of citizens, social entrepreneurs, public authorities and community organisations participating in the energy transition by jointly investing in, producing, selling, distributing and consuming renewable energy. Benefits of energy communities are expected to go beyond counteracting climatic change, including positive regional, economic, and environmental impacts, which are identified as a major drivers of public acceptance (Cohen et al., 2016a).

However, public acceptance and participation in local energy communities is not limited to the acceptance of one specific energy technology or installation, but to the acceptance of all administrative and technological elements needed for a sufficient local energy system. While numerous analyses deal with the acceptance of specific technologies (Paravantis et al., 2018; Roddis et al., 2018; Sposato and Hampl, 2018; Sovacool and Lakshmi Ratan, 2012; Yuan et al., 2011), or optimizing administrative frameworks for energy communities (Baruah and Enweremadu, 2019; Horbach and Rammer, 2018; Khan et al., 2018), existing research lacks comprehensive acceptance assessments of the entirety of local energy systems rather than just their elements. In addition to the underrepresentation of a system-level perspective in acceptance research, some promising emerging technologies are not found in previous studies. In this study, we strive for a system-level understanding of public acceptance, as we posit that the acceptance to specific technologies may not be equal to the sum of its parts when it comes to accepting a community level change in energy infrastructure and provision.

One under-researched technology that could play a key role in a future sustainable energy system is called Power-to-Gas (PtG), which refers to a chemical process for converting surplus electricity into burnable gases like hydrogen and methane. An electricity system aiming for a very high share of renewables needs storage capacity for times of high demand and/or low production from wind, sun and other intermittent sources (see e.g. Lund and Mathiesen, 2016; Ould Amrouche and Bachac, 2016). While the most efficient solution for large-scale electricity storage is pump-hydro storage, its application is limited by many factors, most obviously geographical prerequisites. The gases produced in a PtG process can be fed into the already existing gas grid<sup>1</sup>, and thus do not require additional investment in transport and pipeline infrastructure. While PtG has been investigated from the business and economic point of view, the social perspective and the acceptance of PtG are often left unexplored (Eveloy and Gebreegziabher, 2019; Leeuwen and Mulder, 2018; Mazza et al., 2018). This work is the first to explicitly investigate the acceptance of power to gas technology in local communities.

Previous research on the acceptance of energy communities stresses the importance of attitudes, visual perceptions, perceived environmental harm, perceived energy cost and personal risk as factors that have an impact on an individual's opposition to energy technologies such as coal, natural gas, nuclear power, and wind power plants (Johansson and Laike, 2007; Liebe and Dobers, 2019). The effect of the proximity of these energy infrastructures to homes is also examined in several studies (see e.g. Nelson and Cain, 2017; Bjørn Aaen and Lyhne, 2016; Devine-Wright, 2012), framed under the so-called "Not-in-My-Backyard" phenomenon, whereby the public perceives infrastructure projects as necessary, but opposes these projects in their own neighbourhoods (Schively, 2007). Yet the results of these studies are mixed showing that proximity may have a positive, negative or no impact on acceptance, depending

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<sup>1</sup> On overview legal limitation for the four investigated countries is provided in [https://www.storeandgo.info/fileadmin/downloads/publications/Kreeft\\_G.J.\\_2018\\_-\\_Legislative\\_and\\_Regulatory\\_Framework\\_for\\_Power-to-Gas\\_in\\_Italy\\_Germany\\_and\\_Switzerland.pdf](https://www.storeandgo.info/fileadmin/downloads/publications/Kreeft_G.J._2018_-_Legislative_and_Regulatory_Framework_for_Power-to-Gas_in_Italy_Germany_and_Switzerland.pdf)

on type of power plant and national context considered (Ansolabehere and Konisky, 2009; Ek, 2005; Read et al., 2013).

As Liebe and Dobers (2019) claim, the concept of proximity may play a less important role than social norms in the respective region, in particular how climate change or renewable energies are perceived by the social group to which the individual belongs. Social, group, and cognitive norms have been shown to drive energy related behaviours in various contexts, for example in the adoption of household energy efficiency (Sopha and Klöckner, 2011), energy consumption (Stephenson et al., 2010), and involvement in community energy projects (Kalkbrenner and Roosen, 2016). In the context of building acceptance for a local energy community, it is critical to understand the social and group norm dynamics with respect to the leadership and participatory process to improve acceptability and the success of the community energy transition. Past literature has not yet directly addressed this question, and yet it is one area where policy can be influential by designating leadership roles and creating a regulatory environment for participation. Policymakers often signal support for elements of the energy transition either directly through directives or speeches, or through the enactment of supporting legislation. In this paper, we test the effect of stated support for elements of energy communities by policymakers at different levels of government, local, national, and European. This is a first step in understanding the optimal policy stance with respect to local energy communities in Europe, and helps to understand any positive or negative effects that the support of political opinion leaders may have on acceptance.

This paper aims to fill the gaps in the literature discussed above regarding energy communities, namely, the lack of system-level consideration in the acceptance of energy communities, and the lack of PtG acceptance research. We also add to the policy literature discussing the effects of social norms on acceptance by explicitly considering the role of political opinion leaders in shaping citizen acceptance to energy communities. To do so, this paper presents an analysis of survey data collected from 2,000 households in four European countries, Germany, Austria, Italy, and Switzerland. The survey includes a choice experiment presenting a hypothetical situation where the local energy system is transformed into a sustainable energy system that can include financial contributions from the residents. The experiment is designed to examine the preferences of European households for different configurations of local energy communities in their area.

In the next sections, we provide a detailed explanation of the methodology applied in the survey, followed by the econometric analysis. We then conclude by examining the determinants of social acceptance and the preferred structures for renewable energy communities in our four sample nations.

## 2 Data

This section explains the public acceptance survey conducted in Austria, Switzerland, Italy and Germany between November and December 2017 and provides a descriptive analysis of the responses and the survey sample.

### 2.1 Survey process and questionnaire

The survey implementation included three interactions with each potential participant:

- i) A first contact via phone or email to ensure the willingness of the candidate to participate in the study and to check demographic quotas to achieve representativeness at the country level. Willing candidates completed a screener questionnaire about their basic demographic information.
- ii) Distribution of a booklet through postal mail or email accompanied by a note reminding respondents about the purpose of the study and reaffirming the confidentiality of their responses. The main purpose of the booklet was to provide graphical examples of how a community can look with and without a predominantly renewable energy system. As the visual appearance of an energy technology can have a significant impact on peoples' perceptions thereof, the choice experiment relied on this graphical support material of different scenarios of energy communities in addition to the textual explanations.
- iii) The main questionnaire was administered by phone or email. The first section of the survey included general interest questions, while the second section of the survey was the choice experiment.

Respondents were recruited by the market research firm Efficiency<sup>32</sup> based on a randomized sampling procedure. The final sample comprises 2.000 households, 500 per country (Germany, Switzerland, Italy and Austria). Each of the four country samples is divided into "Sample A" and "Sample B", which correspond to a 50% Online and 50% CATI (by phone with supporting materials sent via postal or electronic mail) method to balance survey mode effects. In the CATI mode, respondents were pre-recruited by a screening questionnaire, after which the booklet was sent (online or via post, as desired by the respondent), and the interviews were conducted upon receipt of the booklet. The availability of the booklet was verified before starting the CATI interviews, to ensure the respondents had the visual representations in front of them during the interview. The telephone interview took about 25 minutes. The online respondents received the booklet via email, and could proceed directly to the web-based version of the survey.

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<sup>2</sup> <http://www.efficiency3.com/en/>

The main questionnaire, as well as the screener and the booklet, are found in the Annex. The screener questionnaire included quotas to ensure a representative sample among the population of Austria, Germany, Switzerland, and Italy. In order to get an adequate sample we implemented a pre-selection with four questions regarding age, profession, hometown, and income. Quotas are found in Table 1 and the demographic distribution of the final sample is given in Table 2.

**Table 1: Defined quotas for the survey sampling process to ensure representability**

<b>Question in the screener regarding the...</b>	<b>Quota</b>
<b>Age</b>	Maximum 35 % per age band, not less than 10 % per age band (see Table 2)
<b>Profession</b>	Minimum of 70 % to be employed (full time & part time)
<b>Area</b>	Maximum 70 % per code <sup>3</sup>
<b>Monthly net income<sup>4</sup> per household</b>	30 % approx. high income – no less than 20 % <sup>5</sup> 40 % approx. middle income – no less than 30 % 30 % low income – no less than 20 % <sup>6</sup>

<sup>3</sup> a) Town/city (with more than 10,000 inhabitants) and b) A village or very small town (with less than 10,000 inhabitants)

<sup>4</sup> Income brackets are derived from national statistics:

[http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=ilc\\_di01&lang=de](http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=ilc_di01&lang=de)

<sup>5</sup> 2.500 Euro (AT), 2.300 Euro (GER), 1.800 Euro (IT), 5.100 CHF (CH)

<sup>6</sup> 1.500 Euro (AT), 1.300 Euro (GER), 1.000 Euro (IT), 3.100 CHF (CH)

**Table 2: Descriptive statistics of the sample**

	Indicator	Germany		Austria		Switzerland		Italy	
		n	percentage	n	percentage	n	percentage	n	percentage
	<b>Respondents per country</b>	500	25.0	500	25.0	500	25.0	500	25.0
<b>1</b>	<b>AGE</b>								
	20-34	115	23.0	108	21.6	105	21.0	97	19.4
	35-45	98	19.6	106	21.2	100	20.0	101	20.2
	46-65	171	34.2	170	34.0	176	35.2	177	35.4
	>65	116	23.2	116	23.2	119	23.8	125	25.0
<b>2</b>	<b>Profession</b>								
	<b>Employed</b>	315	63.0	282	56.4	267	64.6	251	50.2
	full time	257	51.4	230	46.0	261	52.2	201	40.2
	part time	58	11.6	52	10.4	62	12.4	50	10.0
	<b>Not working</b> - Full time University or college student	33	6.6	15	3.0	7	1.4	26	5.2
	<b>Not working</b> – Unemployed, housewife/house-husband or in training	67	13.4	83	16.6	55	11.0	92	18.4
	<b>Not working</b> – retired	85	17.0	120	24.0	115	23.0	131	26.2
<b>3</b>	<b>Area</b>								
	Town/city (with more than 10,000 inhabitants)	334	66.8	263	52.6	232	46.4	372	74.4
	A village or very small town (with less than 10,000 inhabitants)	166	33.2	237	47.4	268	53.6	128	25.6

<b>4</b>	<b>Monthly net income per household*</b>								
	Low	159	31.8	144	28.8	151	30.2	131	26.2
	Middle	163	32.6	171	34.2	171	34.2	213	42.6
	High	178	35.6	185	37.0	178	35.6	156	31.2
<b>5</b>	<b>Gender</b>								
	Female	246	49.2	266	53.2	273	54.6	254	50.8
	Male	254	50.8	234	46.8	227	45.4	246	49.2

\*Income bands were set country-wise: Low / Medium / High in AT were <1,500 € / 1,500 € to 2,500 € / >2,500 €; in DE were <1,300 € / 1,300 € to 2,300 € / >2,300 €, in IT were <1,000 € / 1,000 € to 1,800 € / >1,800 €, and in CH were <3,100 Fr. / 3,100 Fr. to 5,100 Fr. / >5,100 Fr.



Additional socio-demographic characteristics of the respondents were collected including their ownership status regarding their home, the number of the people living in the household, the number of children under age 14, and the education level of the interviewed person.

The next part of the questionnaire focused on general opinions regarding renewable energy and related technologies. These questions are closely related to the social acceptance topic and encapsulate the respondent's general attitudes towards energy and environmental issues, and new energy projects, which have been shown to be important factors in acceptance (Johansson and Laike, 2007; Toke et al., 2008). This section also included questions about the current ownership of energy technologies, heating, cooling, and household appliances. Further questions asked after experiences with any larger plants for the production or storage of renewable energy that may be located in the respondent's neighbourhood. Additionally, information about experiences with their electricity and heat supplier were collected.

## **2.2 Choice experiment**

In order to investigate acceptance of renewable energy communities in the four sample nations, we include a choice experiment in the survey. In a choice experiment, a limited number of hypothetical scenarios are revealed to respondents, and respondents are asked to choose which of the scenarios they would prefer if confronted with the same situation in real life. In every choice set, we showed respondents three alternatives total, two alternatives representing different potential configurations of renewable energy communities and one representing the status-quo in their community. Each of the energy community scenarios (alternatives 1 and 2) contained a number of additional energy production facilities and/or infrastructures for storage and/or transport in contrast to alternative 3, the status-quo, where no additional equipment would need to be installed.

Respondents were informed about the change to the cost structure under each of the alternatives. They were told if an alternative incurred additional costs for installations and operation, these costs were put on top of their monthly electricity bill over the next five years. The cost attribute varied between the values: 0€, 2€, 10€, 25€, 50€, or 100 € for Austria, Germany and Italy, and 0/2/10/25/55/110 CHF for Switzerland. Any scenario depicting a hypothetical local energy community had one of these values was randomly assigned as a cost for this sustainable transition, while the status quo option was always free of additional cost.

Energy communities investigated in our study are combinations of one or more of the following technologies: a wind park, a gas-fired power plant, photovoltaic panels, a PtG facility, and an extension of overhead power lines. Technically meaningful combinations of these technologies were designed

with support from a panel of energy technology experts of researchers from the European Commission funded project Store&Go<sup>7</sup>, to ensure the energy communities depicted were realistic and feasible.

In a complex choice situation, requiring judgment of a combination of individual technologies, previous studies using discrete choice experiments have included icons or pictures to depict attribute levels in order to make the choice options easier for the respondent to digest. This can reduce the potential effects of cognitive disengagement or heuristic choice patterns (see e.g. Cohen et al., 2016b; Campbell et al., 2008). Furthermore, Johansson and Laike (2007) suggest that visual perception and view shed effects have an impact on the acceptance or opposition to renewable energy technologies. Thus, inclusion of visuals demonstrating how each potential technology looks and how the potential energy community will look is highly important in our case. We designed a booklet containing the visual representation of the scenarios from Table 3 located in a suburban landscape for each of the choice options. These pictures were shown together with a text description of the local energy community and associated technologies for each of the available options in each choice set. The images of the visual representations were identical in all four surveyed countries.

**Figure 1:** Example of one illustrated option in a scenario: “[...] there is a wind park with 3 turbines and a power-to-gas facility with connection to the electricity and gas infrastructure [...] which you can see on page 5 in the booklet. If you choose this option, you will be charged 5€ per month.”



Source: Own illustration used in survey.

Respondents were asked to inform us about their most preferred alternative and their least preferred alternative in five consecutive choice sets. Scenarios used in our study are found in Table 3.

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<sup>7</sup> Store&Go is a Horizon 2020 project investigating the potential of power to gas technology, see more at <https://www.storeandgo.info/>

The choice task was introduced to the respondents by the following statement:

*“The following questions deal with different scenarios concerning the energy infrastructure in your neighborhood. In the following, you will see in every scenario 3 options how the electricity demand of your neighborhood can be supplied in the future, all representing the provision of the same amount of electricity at the same level of supply reliability as you experience it today. When a scenario contains the construction of new infrastructure, like a wind power plant, consider these to be approximately 500 m away from your home. One of the alternatives within the scenarios is the current energy production from a mix of different energy sources, both fossil and renewable. It is situated further away from your hometown.*

*Please keep in mind that each of the scenarios of energy provision, whether it involves the construction of new infrastructure in your community or not, comes at a different cost. These costs will be split between all households in your community and the respective share payable by your household will be given along with each of the following scenarios. This sum of money represents a monthly fee and you will be charged for it over the next 5 years. It will be collected by your community by putting them on top of your electricity bill.”*

The statement was followed by an assertion that the booklet would be needed for the next questions and then an explanation of the procedure for the subsequent choice tasks. The actual choice set was preceded by a treatment script for a subset of randomly selected respondents. The treatment script stated that a political representative supported one of the three alternatives in the subsequent choice set. Such support could come from the mayor of the residential municipality, the federal chancellor, or the European Commission. One of these three political representatives was assigned randomly to respondents who received the treatment script, and a recommendation was revealed before each choice set. Additional to the three treatment groups corresponding to the three political representatives, 25% of the sample was assigned to the control group where no political support was communicated.

The support of the respective politician was stated as e.g.: “[...] *Please also consider in your decision that you became aware from media reports that **the mayor of your home town** strongly supports **Alternative I**”.*

**Table 3:** Configurations of renewable energy communities as used in the choice experiment

Scenario	Alternative 1	Alternative 2	Alternative 3
1	Photovoltaic (PV) panels + PtG facility	gas-fired power plant	Status-quo
2	Small gas-fired power plant + power lines	PV panels + PtG facility	Status-quo
3	Three wind turbines + PtG facility	PV panels +overhead power lines	Status-quo
4	Three wind turbines facility + small gas-fired power plant	Three wind turbines + PtG facility + gas-fired power plant	Status-quo
5	PV panels + PtG facility + gas-fired power plant	Three wind turbines facility + overhead power lines	Status-quo

### 2.3 Data analysis methods

As discussed in the description of the choice experiment in Section 2.2, we observe the ranks respondent  $i$  assigns to the three revealed alternatives in five consecutive choice sets. Following economic random utility theory we can conceptualize the ordinal ranking that each respondent  $i$  gives to the  $j=1,2,3$  alternatives as corresponding to the utility level that the respondent assigns to the alternatives (McFadden, 1974). We model directly the latent quantity of the respondent's utility level, where the utility respondent  $i$  assigns alternative  $j$  is denoted  $\eta_{ij}$ . Including a status-quo response in each choice set ensures that the choice sets are feasible and allows an interpretation of our results within a random utility framework (Louviere et al., 2010).

The most frequently used econometric model to analyse discrete choice experiments with ranked outcomes is the rank-ordered logit model (see e.g. Chapman and Staelin, 1982; Hausman and Ruud, 1987; Beggs and Hausman, 1981). However, in its basic form, this model assumes that all respondents have common preference parameters and that independence from irrelevant alternatives (IIA) holds (Hanley et al., 1998). The assumption of similar preference is likely to be violated in our survey, since the sample contains respondents from across four nations. We employ country fixed effects to capture nation-specific heterogeneity in preferences. The alternative-specific rank-ordered probit model is used to relax the IIA assumption by estimating the variance-covariance parameters of the latent-variable errors.

The rank-ordered probit regression allows for specifying the independent variables in two ways: alternative-specific variables, in which the values of each variable vary with each alternative (three alternatives per choice set), and case-specific variables, which vary with each choice set or respondent,

but not between alternatives within a choice set. Formally, the model of the latent utilities can be written as:

$$\eta_{ij} = x_{ij}\beta + z_i\alpha_j + \xi_{ij} \quad (1)$$

where  $x_{ij}$  are the alternative-specific independent variables that include specific characteristics of each option in the suggested scenarios including technologies used, price, and political support. The  $z_i$  are the case-specific independent variables which include respondent  $i$ 's characteristics like age, gender, education. The error term  $\xi_{ij}$  follows a multivariate normal distribution with zero mean and covariance matrix  $\Sigma$ . As the levels of the utilities in (1) are not identified, the model is estimated for the differences in utilities between pairs of alternatives within a given choice set. Hence, if individual  $i$  ranks the three alternatives with alternative 3 as the preferred alternative and alternative 1 is the least preferred alternative, then the probability of this ranking given  $\beta$  and  $\alpha_j$  is the probability that:

$\eta_{i,2} - \eta_{i,3} \leq 0$  and  $\eta_{i,1} - \eta_{i,2} \leq 0$ , and  $\eta_{i,1} - \eta_{i,3} \leq 0$ , jointly.

### 3 Results

The objective of the choice experiment is to identify which configuration of a renewable energy community can increase its acceptance by the local population. The transformation of a municipality into a renewable energy community requires as a precondition a willingness to abandon the status-quo. The status-quo is represented by alternative 3 in our study, and hence we provide our results as the change in probability of choosing alternative 3 under different configurations of the renewable energy community. This section first presents the results for alternative-specific variables including price, technologies, and the level of political support, followed by an overview of case-specific variables including variables such as age, education, and gender. A list of variable names and definitions and the untransformed coefficient estimates from the models are provided in Tables A1 and A2 of the Annex.

The marginal effects in Table 4 and Table 6 are interpreted as the effect of a one-unit increase in the referenced variable on the probability that a respondent prefers the status quo over a transition to a renewable energy community. The marginal effects are calculated with all other variables fixed to their sample means. In the case of price, if the monthly costs of a proposed renewable energy community is increased by one euro, the probability that a respondent prefers maintaining the status-quo increases by 0.14% (see first column of Table 4). While a significant relationship between the costs of transitioning to a renewable energy community and the acceptance of such is not surprising, the magnitude of the effect is relatively moderate. Even under additional monthly costs of about 70€, the probability a respondent prefers a transition to a renewable energy community over the status quo decreases by only 10%.

Looking next at the impact of specific technologies, we find that including PV and PtG in the configuration of a renewable energy community significantly increases the probability that a respondent prefers a new local energy community to the status quo by ~3% and ~1.5%, respectively. Including gas plants in a local energy community significantly decreases the social acceptance of such a transition, increasing the probability a respondent prefers the status quo by 1%. A negative effect on acceptance of the same magnitude is identified for overhead power lines. This is unsurprising due to the common findings of past literature that power lines negatively affect the view shed and have perceived deleterious health effects (Cohen et al., 2016a; Soini et al., 2011). In this respect, our results show it is important to investigate energy community solutions that require as little additional electricity transmission capacity as possible, at least when transmission involves visible overhead lines. Such solutions could involve PtG, which stores excess electricity locally, instead of feeding it into the distribution/transmission grid, and can transport energy through gas pipelines. Interestingly, the addition of wind farms to a renewable energy community does not show an effect on acceptance, with a marginal effect that is not statistically significant. While the positive low-carbon and sustainable nature of wind power is widely accepted, the long-range visibility, noise, and local environmental concerns can lead to opposition to local wind farm siting and has been shown to decrease local property values (Cohen et al., 2014; Friedl and Reichl, 2016; Sims and Dent, 2007).

Under the “political support” heading, Table 4 reports the findings regarding the administrative dimension investigated in our choice experiment, namely the effect of political support for a certain alternative from various opinion leaders. In this model, country-specific effects are estimated, meaning that the effect of support from each administrative entity, local, national, and EU, is allowed to vary across the four countries investigated. In Germany and Austria, political support is not shown to influence responses to the choice experiment. However, in case of Switzerland we find a positive effect from support of the local government. Specifically, if a Swiss mayor was said to support a respective alternative, the probability that the endorsed renewable energy community project is preferred increases by 2.2%. In contrast to the Swiss findings, the results for Italy show that national and EU level support increase the level of acceptance while local support has no effect. These results show the importance of investigating and taking into consideration the specific political situation of a country and trust in different policymaking branches; while Italians put more weight on the suggestions of national or EU opinion leaders, the Swiss prefer the advice of their local leaders. These findings are in line with the analysis of Kollmann & Reichl (2015) who find a strong interdependency of trust in the governmental institutions and a population’s willingness to accept environmental policies associated with tax increases. Their analysis also shows Switzerland as one of the nations with highest confidence in their local government, with Italy exhibiting less trust in local governments. Similarly, the Corruption Perceptions Index 2017<sup>8</sup> finds that Switzerland has the 3<sup>rd</sup> lowest corruption rating for

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<sup>8</sup> [https://www.transparency.org/news/feature/corruption\\_perceptions\\_index\\_2017](https://www.transparency.org/news/feature/corruption_perceptions_index_2017)

government officials while Italy is significantly higher with the 54<sup>th</sup> lowest corruption rating. Our results suggest that these broader issues of trust in governmental bodies can also affect their efficacy as opinion leaders in improving acceptance and participation in the energy transition.

**Table 4:** Marginal effects of alternative specific variables on the acceptance of renewable energy communities

<b>Variable</b>	<b>Marg. Eff.</b>	<b>Std. Err.</b>	<b>z-statistic</b>	<b>P&gt;z</b>
<i>Price</i>	0.0014***	0.0000	-27.37	0
<b><i>Technology</i></b>				
<i>PV</i>	-0.0298***	0.0043	6.85	0
<i>PtG</i>	-0.0139***	0.0030	4.62	0
<i>Gas plant</i>	0.0106***	0.0039	-2.72	0.007
<i>Wind farm</i>	-0.0064	0.0044	1.45	0.147
<i>Power lines</i>	0.0109***	0.0028	-3.83	0
<b><i>Political support</i></b>				
<i>Germany</i>				
<i>Mayor</i>	-0.0048	0.0073	0.66	0.51
<i>Chancellor</i>	0.0014	0.0067	-0.22	0.829
<i>EU</i>	0.0048	0.0067	-0.72	0.471
<i>Austria</i>				
<i>Mayor</i>	0.0048	0.0076	-0.64	0.524
<i>Chancellor</i>	-0.0094	0.0080	1.17	0.243
<i>EU</i>	0.0015	0.0074	-0.21	0.834
<i>Switzerland</i>				
<i>Mayor</i>	-0.0225***	0.0086	2.62	0.009
<i>Chancellor</i>	-0.0088	0.0083	1.07	0.284
<i>EU</i>	-0.0108	0.0078	1.4	0.161
<i>Italy</i>				
<i>Mayor</i>	-0.0114	0.0085	1.33	0.182
<i>Chancellor</i>	-0.0269***	0.0091	2.95	0.003
<i>EU</i>	-0.0351***	0.0100	3.51	0

\*\*\* marginal effect is significant on the 1% level; marginal effects denote the change in the probability a respondent prefers the status quo option over a transition to a renewable energy community.

We derive willingness to pay (WTP) estimates for the presence of specific technologies in the local energy community based on the results of the rank-ordered probit model shown in Tables 4, 6, and A2. WTP estimates and their 95% confidence intervals (CI) are calculated as  $-\frac{\beta_{tech}}{\beta_{price}}$  where  $\beta_{price}$  is the coefficient on the “Price” variable in Table A2 of the Annex, and  $\beta_{tech}$  is the coefficient for the variable of the technology type specified. The quantities describe how much more in monthly electricity cost over the next 5 years the average respondent is willing to pay if the associated technology is included in the local energy community. The results of this exercise reiterate those shown in Table 4 and reaffirm the results of past studies, most notably that local consumers are willing to pay

higher electricity rates for an electricity mix with a substantial proportion of solar-generated power (Vecchiato and Tempesta, 2015; Cicia et al., 2012; Borchers et al., 2007). Our estimate of a €29.52 per month willingness to pay for substantial solar generation is in line with past WTP estimates from choice experiments that find a value of ~€60 in Italy (Cicia et al., 2012), ~€12 in Italy (Vecchiato and Tempesta, 2015), and ~€21<sup>9</sup> in the USA (Borchers et al., 2007). Though it is important to note that estimates are not perfectly comparable due to differences in choice set design and the specification of solar-power provision between studies. Further results from Table 5 show that the presence of power-to-gas and wind farms in the local energy community increase WTP for the transition by about €9 per month. In contrast, gas fired power plants and more transmission lines in the energy community decrease the WTP for the transition by €10.32 and €11.59, respectively.

**Table 5:** Willingness to pay estimates (€ per month) for technologies to be included in local energy communities

	<b>PV</b>	<b>PtG</b>	<b>Gas plant</b>	<b>Wind farm</b>	<b>Power lines</b>
<i>WTP estimate</i>	29.52	8.53	-10.32	9.7	-11.59
Lower 95% CI	21.26	2.68	-19.29	0.71	-18.29
Upper 95% CI	37.79	14.38	-1.36	18.7	-4.88

CI – is the 95% confidence interval bound for the estimate derived by the delta method

Turning the focus to the case-specific characteristics shown in Table 6, we find statistically significant effects for the age, gender, and education level of the respondent, and the presence of children in the household. All the other tested factors including income, rural vs. urban residence, previous knowledge about PtG, and negative experiences with the electricity provider show no effect on social acceptance in our sample. The country fixed effects estimates show that the propensity to choose the status quo as the most preferred option is not systematically influenced by the country of residence. Considering the effect of age, we observe that compared to the group of 20 to 35 years old, being in the groups of 35-45 and 45-65 year olds increases the probability of choosing the status-quo as the most preferred option by about 1.5%. The middle-aged groups are thus generally less accepting on a transition to a renewable energy community, though interestingly this effect is not present for the over-65 age group. Female respondents are also more likely to prefer the status quo compared to males. We find weak evidence that the respondent’s level of education has an effect on the likelihood to accept a proposed renewable energy community. The marginal effects of education are interpreted relative to the omitted category of people with a university degree. Compared to this group, respondents with secondary or elementary school as their highest level of education are 2% more likely to prefer the status quo; however this effect is only weakly statistically significant (at the 10% level). On the other hand, households with kids have a significantly lower probability to prefer the status-quo, decreasing the probability of

<sup>9</sup> Converted from 2007 USD to 2018 Euros based on CPI rates and Jan 23, 2018 Euro to USD exchange rate.



choosing the status quo by 2%. This last finding may suggest that parents consider a longer-term perspective in their decisions with respect to their community energy systems than others do.

**Table 6:** Marginal effects of socio-demographic factors determining social acceptance of renewable energy communities

Case-specific variables	Marg. Eff.	Std. Err.	z-statistic	P>z
Germany	-0.0001	0.0077	-0.02	0.986
Austria	0.0047	0.0075	0.63	0.53
Italy	-0.0128	0.0085	-1.5	0.134
Age 35-45	0.0188**	0.0092	2.04	0.042
Age 45-65	0.0160*	0.0081	1.96	0.05
Age >65	0.0128	0.0122	1.05	0.292
Part time job	0.0143	0.0095	1.5	0.133
Student	0.0013	0.0149	0.09	0.929
Housewife/husband	-0.0096	0.0078	-1.23	0.219
Retired	0.0086	0.0101	0.85	0.394
Rural	0.0089	0.0057	1.56	0.119
Female	0.0127**	0.0054	2.33	0.02
Elementary or secondary school	0.0220*	0.0117	1.89	0.059
Professional training	0.0020	0.0077	0.26	0.793
A-levels	0.0006	0.0075	0.09	0.932
Household size	0.0040	0.0032	1.27	0.204
Kids	-0.0189**	0.0077	-2.46	0.014
Protest	0.0091	0.0152	0.6	0.549
Ptg-knowledge	-0.0007	0.0062	-0.12	0.906
Years in home	0.0003	0.0004	0.78	0.434
Owner	-0.0037	0.0061	-0.62	0.537
Near plants	-0.0001	0.0055	-0.01	0.989
Negative provider experience	0.0062	0.0081	0.77	0.442
Power outage	-0.0017	0.0081	-0.21	0.835
High-income	-0.0008	0.0071	-0.11	0.915
Middle-income	0.0053	0.0075	0.71	0.477

\*\*\* marginal effect is significant on the 1% level; \*\* marginal effect is significant on the 5% level; \* marginal effect is significant at the 10% level. The marginal effects are interpreted as the change in the probability of choosing the status quo as the most preferred option for a one-unit increase in the associated variable. The omitted category for country-comparison is Switzerland. The omitted category for age is 20 to 35 years old. The omitted category for occupation is full time working respondents. The omitted category for education is University or college degree. The omitted category for income is low income.

#### 4 Conclusion and Policy Implications

This article investigates the acceptance of local renewable energy communities in four European countries, Germany, Austria, Italy, and Switzerland. We examine the preferences of citizens of these nations regarding various feasible configurations of renewable energy communities and the technologies used in potential transformations. As a direct policy contribution, we investigate whether signalled support for specific configurations of energy communities from political entities at the local, national, and EU levels, can increase the acceptance of renewable energy transitions. Data for this study come from a choice experiment survey that collected 500 responses from each sample nation.

The data are analysed using a rank-ordered probit model with country fixed effects to avoid the IIA assumption intrinsic in the logit model and to control for preference heterogeneity across nations.

We find that if the technologies of PV and PtG are substantially used in the proposed local renewable energy system this increases the probability a respondent accepts the local energy transition. We complete the first ever assessment of the social acceptance of power-to-gas, and find that this storage type likely will not face the same acceptance problems as have been noted for pump-hydro in some instances (Steffen, 2012). In contrast, no strong recommendation for including wind power in the configuration of a renewable energy community can be made based on our results. This likely reflects the conflicting outcomes of local wind generation, where on one hand local wind farms can decrease property values (Sims and Dent, 2007), on the other hand green power from wind sources may be preferred to conventional generation sources (Borchers et al., 2007). In line with these results on acceptance, we find a positive WTP for wind in the local electricity generation mix of €9.70 per month, and a much higher WTP for solar of €29.52 per month, generally reflecting the results of past choice experiment studies (e.g. Vecchiato and Tempesta, 2015; Cicia et al., 2012; Borchers et al., 2007). Counter to the beneficial effects for social acceptance from some of the studied renewable energy technologies, including the more conventional infrastructure of overhead power lines and natural gas generators in the local energy system is shown to decrease local support. Hence, we conclude that the type of energy generation included in a local energy community project has to be carefully chosen in accordance with local preferences to ensure that the local energy transition will meet high levels of support from affected citizens.

Looking at the socio-demographic characteristics, we find effects of age, gender and education on social acceptance: older groups, females and respondents with lower education have lower acceptance for renewable energy systems. Although the effect of education is only weakly statistically significant. From the policy perspective, in order to increase the acceptance of renewable energy community projects, our results suggest that educational programs and advertising campaigns could be targeted towards these less accepting groups of citizens.

In the context of building acceptance for a local energy community policies are important, both in their ability to make the project cheaper or easier to complete, but also in terms of their potential signalling of support for a project from a policymaking entity. Politicians and governmental institutions can serve as opinion leaders for energy related topics. In this paper, we test the effect of hypothetical stated support from local, national, and EU-level politicians on the acceptance of transitions towards local renewable energy communities across four European nations. We find that political support can indeed play a role for the acceptance of such communities; however, the effect differs between countries. For the Italian case, support on national or EU level has a positive effect on social acceptance, while for Switzerland only the support of the community's local leader can enhance acceptance levels. No such effects are found for Germany and Austria, and we find no evidence that political support for a

project can lead to ‘pushback’ in the form of lower acceptance across the four nations tested. These results confirm the necessity to consider not only the technical or operational configuration of a project, but also the country-specific political, and group norms. Those political entities that the public has more confidence in can be chosen to spearhead the push towards energy transition, which may increase acceptance and participation within some national contexts.

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