newcomers
EXPLORING NEW ENERGY COMMUNITIES

New Clean Energy Communities in a Changing European Energy System (NECOMERS)

Deliverable 5.1

Electricity consumption of members in a newly developed top-down energy community

Version: 2.0

WP5: Potential to stimulate conservation behaviour and demand response

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Summary of NEWCOMERS

In its most recent Energy Union package, the European Union puts citizens at the core of the clean energy transitions. Beyond policy, disruptive innovations in energy sectors are challenging the traditional business model of large energy utilities. One such disruptive, social innovation is the emergence of new clean energy communities ("NEWCOMERS").

The possible benefits of these "NEWCOMERS" for their members and for society at large are still emerging and their potential to support the goals of the Energy Union is unclear. Using a highly innovative holistic approach – drawing on cutting edge theories and methods from a broad range of social sciences coupled with strong technical knowledge and industry insight – the NEWCOMERS consortium will analyse European energy communities from various angles. By taking an interdisciplinary approach and through employing co-creation strategies, in which research participants are actively involved in the design and implementation of the research, the NEWCOMERS project will deliver practical recommendations about how the European Union as well as national and local governments can support new clean energy communities to help them flourish and unfold their potential benefits for citizens and the Energy Union.

Summary of NEWCOMERS's Objectives

As subsidiary objectives, the NEWCOMERS project aims to

- provide **a novel theoretical framework based on polycentric governance theory**, combined with elements from social practice theory, innovation theory and value theory, in which the emergence and diffusion of new clean energy communities can be analysed and opportunities for learning in different national and local polycentric settings can be explored;

- develop a **typology of new clean energy community business models** which allows to assess the different types of value creation of "newcomers" as well as their economic viability and potential to be scaled up under various conditions;

- identify the **types of clean energy communities that perform best along a variety of dimensions**, such as citizen engagement, value creation, and learning, and their potential to address energy poverty, while being based on sustainable business models;

- investigate the **regulatory, institutional and social conditions**, at the national and local level which are favourable for the emergence, operation and further diffusion of new clean energy communities and enable them to unfold their benefits in the best possible way;

- explore **how new clean energy communities are co-designed with their members' (i.e. citizens' and consumers') needs**, in particular whether new clean energy communities have the potential to increase the affordability of energy, their members' energy literacy and efficiency in the use of energy, as well as their members' and society's participation in clean energy transition in Europe;

- deliver **practical recommendations based on stakeholder dialogue** how the EU as well as national and local governments can support new clean energy communities to make them flourish and unfold their benefits in the best possible way;

- offer citizens and members of new clean energy communities a **new online platform 'Our-energy.eu'** on which new clean energy communities can connect and share best practices and interested citizens can learn about the concept of energy communities and find opportunities to join an energy community in their vicinity.

Find out more about NEWCOMERS at: https://www.newcomersh2020.eu/

NEWCOMERS Consortium Partners

Logo	Organisation	Type	Country
	Institute for Environmental Studies (IVM), Vrije Universiteit Amsterdam (VUA)	University	The Netherlands
	International Institute for Industrial Environmental Economics (IIIEE) at Lund University (LU)	University	Sweden
	Environmental Change Institute (ECI), University of Oxford (UOXF)	University	United Kingdom
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	Leibniz Institute for Economic Research (RWI)	Research organisation	Germany
	Consensus Communications (CONS)	Private for Profit (SME)	Slovenia
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1   EXECUTIVE SUMMARY

Clean energy communities aim to promote renewable energy as well as energy conservation (Gui and MacGill, 2018; Mlinarič et al., 2019). They are social networks and often create a new social identity among their members. The identification as a member of an energy community can thereby lead to new environmentally friendly behaviours. Initial qualitative evidence indeed suggests that involvement in energy communities encourages sustainable energy behaviours (Biddau et al., 2016; Middlemiss, 2011). Based on survey data, Sloot et al. (2018) observe that being part of an energy community potentially enhances community members' motivation to engage in energy conservation. Yet, none of these studies accounted for the self-selection of individuals into energy communities.

This study investigates to what extent the membership in an energy community induces energy conservation. It is the first study to explore this relationship in a randomized controlled field experiment, in which random assignment into the energy community allows for the estimation of the causal effect of community membership on electricity conservation. In our randomized controlled trial, we co-created the energy community in collaboration with GEN-I, the largest electricity utility in Slovenia. GEN-I asked around 10,000 of their customers if they would like to take part in a research study. Of the more than 1,000 customers who were willing to participate, we chose 300 customers to be part of the core study. Of these 300, half of the participants were randomly assigned to the newly developed energy community. It is therefore a top-down energy community that could in principle be set up in a similar way by any energy utility in Europe.

Our trial therefore has a number of strengths. The exogenous assignment of customers in the energy community prevents effects like self-selection and allows the identification of the causal effect of community membership on energy conservation. The collaboration with an energy utility enables testing the effects in the proper study population. Furthermore, we can study actual energy consumption behaviour instead of self-reported consumption or motivations to conserve energy, which other studies often have to rely on. Moreover, the concrete setup of the energy community – top down by a large utility – allows, in case of success, a relatively easy imitation by other European utilities. In contrast to grassroots energy communities, such an approach would enable a faster upscaling and further dissemination of energy communities and their benefits for society.

Because energy communities are generally diverse (Hansen and Barnes, 2021), results related to an energy community should be generalized with caution, and the specific characteristics of the energy community should be considered. Our co-created energy community was named *GEN-I Energy Community* and with 150 members the largest energy community in Slovenia. During a period of three months, the community received, among others, monthly newsletters with energy saving tips, testimonials, comparison reports of electricity use within and outside the community, and members had access to an interactive virtual portal. Originally, it was planned

to organize physical meetings among the members of the energy community who all live near or in Ljubljana, the capital of Slovenia. Due to the COVID-19 pandemic, physical meetings were not possible during the study period. The community can therefore be characterized as a virtual energy community, in which virtual interactions were possible and stimulated.

To identify the pure community effect and not the effect of a treatment that comprised a multitude of different elements (cf. Andor and Fels, 2018), among others a variety of information and different nudges, we gave the control group the same information and nudges, except for the community elements. In particular, the control group also got monthly newsletters and had access to a virtual portal. The energy community group was motivated to reduce electricity consumption by framing energy conservation as a community effort and to enable social learning by granting the opportunity of communication between the energy community members.

Our results suggest that the membership in the *GEN-I Energy Community* had not a considerable energy conservation effect. The absence of an effect may be caused by the fact that there is actually no conservation effect related to energy community membership or that effects for different groups cancel each other out. We therefore conducted several heterogeneity analyses regarding, for instance, baseline consumption, environmental concern, social concern, and social identity. In all heterogeneity analyses, we could not find any subgroup for which a saving effect was detected. One possible explanation is that group identity among community members did not evolve as expected in our setting.

Our results illustrate that initiating energy communities top down is difficult. Grassroot energy communities have the advantage that only self-motivated members are active. Yet, it is not clear if such models can scale up to a meaningful contribution for the energy transition. Top-down energy communities could be easier to scale, however, it is unclear if or how exogenous assigned members can be motivated to really act in the community and develop a group identity.

Yet, our study is only a first step in this research line. We see several possibilities why energy communities in general and also such top-down energy communities can be successful in general and with regard to energy conservation, despite our results so far. First, in Deliverable 5.2, we will investigate the longer-term effects and in particular the interaction effects of membership in the *GEN-I Energy Community* with behavioural interventions. Extensive literature has shown the effectiveness of behavioural interventions on stimulating electricity conservation (e.g. Andor and Fels, 2018; Buckley, 2020). While these interventions usually focus on regular customers of energy suppliers, to our best knowledge, they have not been applied in the context of clean energy communities so far. Thus, while we find that membership in the *GEN-I Energy Community* alone does not cause a conservation effect, membership might increase the effect of behavioural interventions. Energy communities allow for testing the combination of new technologies with interventions that harness the potential of the new social network.

Second, in this study we only observe a period of five months. It might be that it may take longer to initiate an energy community, e.g. to build trust, explore options and establish social contacts in the community. Third, there is a growing literature providing evidence that causal effects measured in a particular study population and set-up depend on the particular context and the implementation partner (e.g. Allcott, 2015; Andor et al., 2020b; Dehejia et al., 2021; Peters et al., 2018; Vivalt, 2020). Based on her finding that generalizability between different programs and settings is often limited for many types of interventions, Vivalt (2020) recommends conducting impact evaluations in multiple settings with varying contexts. These arguments seem particularly appropriate in the context of energy communities, which are generally so diverse. In addition, it could be that the location and the time mattered. In comparison to, for example, most German electricity customers, Slovenians receive their electricity bill more frequently (monthly vs. yearly), with all the associated side effects, such as salience of energy costs and feedback on the consumption. The GEN-I customers even already had a virtual portal showing some of the information the *GEN-I Energy Community* portal offered. In terms of time, the COVID-19 pandemic is certainly very special. Due to the pandemic, the implementation of physical meetings was not possible during our study period. This could be a central reason why identity with the community and interactions were rather low. Other impacts of the pandemic are more difficult to assess. In conclusion, we therefore see our findings as the beginning of a research stream that explores the potential for initiating energy communities and properly assesses the impact of community membership on energy conservation.

2 Introduction

The NEWCOMERS project aims to explore how new clean energy communities develop as well as under which polycentric settings energy communities evolve and under what conditions such initiatives are supressed. At a national level, the project will assess regulatory, institutional, and social conditions, which support the emergence of new clean energy communities. The NEWCOMERS project applies a polycentric framework developed in WP 2 (van der Grijp et al., 2019) to analyse the development of the energy community sector in different European countries.

In the NEWCOMERS project, energy communities and regulatory conditions are analysed in six European countries (NL, SE, UK, DE, IT, SI). These countries were selected because they differ in aspects, which can be assumed to be relevant for the presence of energy communities, such as energy generation, regulations, organisation of the electricity market and diversity of actors.

The 'Clean Energy for all Europeans' package (European Commission, 2016) as well as 'The European Green Deal' (European Commission, 2019b) both emphasize the role of citizens and renewable energy communities in the transformation process towards more sustainable energy systems. Besides, energy efficiency throughout the entire energy chain is set as one of the main

goals of this process (European Commission, 2015). Energy conservation, which includes improvements in end-use efficiency, can assist with system-level efficiency. End-use efficiency can imply a higher overall energy use, for example if with little more heating fuel input a larger space is heated. Conservation, on the other hand, implies reducing overall energy use. One way for energy utilities to contribute to this goal could be to set up energy communities among their customers.

Several studies based on surveys conducted among members and non-members of energy communities analyse the (self-reported) impact of community membership on energy conservation behaviours. Hoppe et al. (2019) show a self-reported association of the aforementioned as well as a positive impact of the length of community membership. Sloot et al. (2018) find a positive relationship between energy community membership and self-reported sustainable energy behaviours, e.g. energy saving measures, thermostat setting, efficiency of appliances. In another series of conducted studies, Sloot et al. (2019) show that besides financial and environmental motives for joining an energy community, being part of a community can also be an important motivation why individuals engage in clean energy communities. They argue that financial motives are probably overrated, whereas the community aspect is a rather underrated motive of joining an energy community.

However, all these studies did not account for the self-selection of individuals into energy communities and might thus suffer from selection bias (Heckman, 1979; Tiefenbeck et al., 2019) as individuals usually opt into participating in such communities owed to their personal preferences and environmental attitudes, etc. In addition, real consumption data is often missing to validate the survey results against hard facts and to avoid further problems such as social desirability bias.

To avoid the selection problem, we co-created an energy community in cooperation with GEN-I, the largest Slovenian electricity supplier. Households were randomly assigned to the energy community and a control group after completing a survey and being chosen for the study. The energy community was named *GEN-I Energy Community* (in Slovenian "Energetska skupnost") and with 150 members the largest energy community in Slovenia. We implemented an interactive online portal that allows participants in both groups to monitor their daily electricity consumption. Moreover, participants in the energy community could compare their consumption relative to the average community member and had access to a forum with weekly polls and the possibility to discuss with other community members, for example, about the effectiveness and convenience of various energy efficiency measures. Additionally, they were given information of the communities' energy conservation performance relative to the rest of the study participants. Electricity consumption was measured on quarter-hourly level via smart meters. To our knowledge, this is the first study to explore the relationship between energy community membership and energy conservation behaviour in a randomized controlled field experiment.

We expected that *GEN-I Energy Community* members develop a new social identity as members of a group that shares the joint aim of conserving energy resources. This newly created social identity should raise individuals' awareness of their own electricity use as well as their motivation to engage in conservation behaviours. Eventually, we expected that these mechanisms trigger a reduction in the overall household electricity use of energy community members, compared to non-community members.

We do not find a significant effect of the membership in the *GEN-I Energy Community* on energy consumption behaviour and particularly not on energy conservation. Consumption patterns of both groups remain relatively equal during the whole study period. We conduct several heterogeneity analyses regarding, for instance, baseline consumption, environmental concern, social concern, and social identity. In all heterogeneity analyses, we could not find any subgroup for which a saving effect was detected.

One explanation for our null effects might be that group identity among community members did not evolve as expected in our setting. For instance, Rodrigues et al. (2020) show that user engagement in an energy community was successful via a variety of activities, including physical meetings and workshops. In contrast to our expectations, we found little user engagement on the online platform in terms of number of log ins, comments to posts and sharing own experiences. With regards to this, our findings are in line with Glogovac et al. (2016) who also find only little engagement among new users of the online environmental engagement platform Ducky. Ableitner et al. (2020) observe in their study that the sense of community within their top-down created peer-to-peer trading community is existing only to a very limited extent.

2.1   Role of this deliverable in the project

Based on a randomized controlled trial, this deliverable analyses the impact of being part in an energy community, namely the *GEN-I Energy Community*, on energy consumption using econometric methods. Specifically, we focus on electricity consumption, drawing on detailed consumption data of households who are equipped with smart meters. Close monitoring as well as two surveys conducted before and after the intervention among the study participants allow for the assessment of conservation behaviour that could be introduced by the membership in the clean energy community. With this approach, we can test whether the top-down creation of energy communities by energy utilities can be a successful strategy to meet the requirements of the EU energy efficiency targets.

2.2 Approach

In collaboration with GEN-I, we conducted a randomized controlled field experiment and co-created the *GEN-I Energy Community*. To this end, we ran a pre-intervention survey among around 10,000 GEN-I customers from the wider Ljubljana area in June and July 2020. 1,082 GEN-I customers submitted the pre-intervention survey and gave consent to share their smart meter

electricity use data. Out of these, we selected a relatively homogenous group of 300 households as core study participants, among others, based on household size (see 4.1). The 300 core study participants were randomly assigned to either the *GEN-I Energy Community, i.e. the treatment group,* or the control group. Summary statistics for the control and treatment groups show that there are no considerable differences between the two groups in terms of household characteristics and behaviour, such as sociodemographic characteristics, personal attitudes and electrical equipment. During a period of three months, starting from December 2020, those who were part of the *GEN-I Energy Community* received monthly newsletters with energy saving tips, testimonials, comparison reports of electricity use within and outside the community, and members had access to an interactive virtual portal. To identify the pure community effect and not the effect of a treatment that comprised a multitude of different elements (cf. Andor and Fels, 2018), among others a variety of information and different nudges, we gave the control group the same information and nudges, except for the community elements (see 4.2). After the end of the intervention, a post-survey was conducted as well. For our analysis, we use daily electricity consumption as main variable and apply a difference-in-differences approach. In addition, we conduct heterogeneity analyses with ordinary least squares (OLS) methods.

2.3   Structure of the document

The remainder of this document is structured as follows: The next section provides more detail on the background of energy communities. Section 4 describes the study implementation (4.1) and experimental design (4.2) as well as the details on the power analysis conducted beforehand (4.3). The subsequent section 5 describes the results of our analysis and provides details on the average treatment effect (5.1) as well as on heterogeneous treatment effects (5.2). Section 6 provides concluding remarks and policy implications.

3   Background

Current mega trends in the energy sector such as decarbonization, decentralization and digitalization have led to the evolution of new energy service business models (see also Deliverable D2.2 of this project Mlinarič et al., 2019). Additionally, the 2030 goals of the European Union (EU) target considerable reductions in Greenhouse Gas (GHG) emissions combined with increased shares of Renewable Energy Sources (RES) and improved energy efficiency.

The 'Clean Energy for all Europeans' package (European Commission, 2016) as well as 'The European Green Deal' (European Commission, 2019b) both emphasize the role of citizens and renewable energy communities in the transformation process towards more sustainable energy systems. Besides, energy efficiency throughout the entire energy chain is set as one of the main goals of this process (European Commission, 2015). This also includes

improvements in energy end-use by consumers. Energy conservation, which includes improvements in end-use efficiency, can assist with system-level efficiency. End-use efficiency can imply a higher overall energy use, for example if with little more heating fuel input a larger space is heated. Conservation, on the other hand, implies reducing overall energy use. One possibility for energy utilities to reach this goal could be the external set up of energy communities.

In the framework strategy, consumers are put at the heart of the transition from traditional to renewable energy sources, allowing them to actively take part. The EU has strengthened the consumers' position not only regarding the type of energy they want to use and which supplier to choose, but also in terms of active involvement in investment into new RES or their generation (European Commission, 2019a). The aim is thus that citizens will be able to support the transition towards more sustainable energy systems in a more active way (Blasch et al., 2021).

In this context, citizen-led energy communities have emerged. Within the NEWCOMERS project (Deliverable D2.1), energy communities are defined as "associations of actors engaged in energy system transformation for reduced environmental impact, through collective, participatory, and engaging processes and seeking collective outcomes" (van der Grijp et al., 2019, p. 23). There is a growing literature on citizen-led energy communities and their benefits. Wörner et al. (2019) show in their literature review, how distributed energy resources can be integrated into the energy market to meet the challenges of future energy demand. Energy communities have been assessed by some as providing a great potential with regards to the further development of the energy sector and energy transition such as the democratization of energy generation, increased flexibility and security of energy supply, citizen involvement in the energy transition, enhanced energy literacy among customers and increased affordability of energy (Blasch et al., 2021; Hoppe et al., 2019; Sloot et al., 2019; Tarhan, 2015).

Energy communities can focus on different aspects of energy generation. For example, in the NEWCOMERS project *Dalby Solarvillage* in Sweden, *Duurzaam Soesterkwartier* in the Netherlands and *Solidarity & Energy housing community* in Italy have a strong focus on producing energy. Communities increasingly rely on smart technology (ICT) to achieve their aims. For instance, *Energy Local* in the UK equips members with smart meters to record when electricity is used, and many members of the German *Sonnen Community* have employed long-life lithium batteries.

In general, clean energy communities are characterised by their aim to promote renewable energy as well as energy conservation (Gui and MacGill, 2018; Mlinarič et al., 2019). They are usually social networks, with interaction between community members that may be conducive to creating a new social identity within their members. Multiple authors (e.g. Bomberg and McEwen, 2012; Rogers et al., 2008; Seyfang et al., 2013) have stressed the importance of a shared identity for progress and success in the field of renewable energy projects. Initial qualitative evidence suggests that

involvement in energy communities may indeed encourage sustainable energy behaviours (Biddau et al., 2016; Middlemiss, 2011). Sloot et al. (2018) observe based on survey data that being part of an energy community potentially enhances community members' motivation to engage in energy conservation.

An extensive literature has considered the effect of behavioural interventions on stimulating electricity conservation (Allcott, 2011; Brandon et al., 2019; Tiefenbeck et al., 2019; Andor and Fels, 2018; Buckley, 2020). While these interventions usually focus on regular customers of energy utilities, to our best knowledge, they have not been applied in the context of energy communities so far. Energy communities have distinct features that make the application of behavioural interventions to stimulate conservation behaviour and demand response very promising. Being part of an energy community provides new opportunities to interact with other members of the energy community, which may contribute to social learning, where people acquire new behaviours through observing and learning from their social environment (Bandura, 1977). Moreover, energy communities allow for testing the combination of new information and communication technologies with interventions that harness the potential of the new social network. An example of such a technology is a digital portal where participants can monitor their energy consumption and interact with each other via a forum. In our research project, we will investigate the interaction effect of the *GEN-I Energy Community* with behavioural interventions in Deliverable D5.2.

4 Sampling, data, and experimental design

4.1 Sampling and data

To assess the effect of energy community membership on energy conservation, we cooperated with GEN-I, the largest electricity utility located in Slovenia, to implement a field experiment among their customers. In 2020, GEN-I supplied around 380,000 customers in Slovenia, Croatia and Austria with electricity and natural gas (GEN-I 2021).

Out of GEN-I's customer base, a sample of around 10,000 Slovenian households, who are equipped with smart electricity meters, were randomly selected and invited by email in June and July 2020 to participate in the study. As a requirement for participation, customers needed to fill in an online survey and agree to share their electricity use data for the duration of the study. For the purpose of the project, only customers located in the region around the Slovenian capital Ljubljana were selected.

In total, 1,082 customers submitted the survey and agreed to share their smart meter electricity use data. The selection of the final study sample was primarily governed by the necessities of a second experiment, which we conducted subsequently to the study period of the present study with the same study sample. This second field experiment will be documented in

Deliverable D5.2. It investigates the interaction effects of behavioural interventions and energy community membership on energy consumption and involved the distribution of "smart shower heads" for this purpose. As the availability of these shower heads was limited out of budgetary reasons, the final sample size was restricted to 300 households. The selection of these 300 households was determined based on their stated willingness to also participate in the second experiment and their stated fulfilment of the technical requirements needed for the second experiment (384 households). Out of these 384 households, the final sample selection was conducted by excluding households with more than 5 members and more than 2 shower heads, in order to increase the homogeneity of the sample. The remaining group of 782 households who gave consent to share their electricity use data but were not selected into the core study will be investigated as an additional control group in Deliverable D5.2.[1] For the present Deliverable (D5.1), the selection process implies a more homogenous core study group, which has advantages for the balancing of the experimental groups.

Of the initially 300 selected households, smart meter electricity data is available from 288 households. The 12 households whose electricity data is not available, dropped out of the study for various reasons, e.g. including moving houses, lack of technical knowledge, lack of Wi-Fi internet, and renovations; or they faced issues in processing the data.

We use quarter-hourly electricity consumption data, measured via smart electricity meters, from the beginning of October 2020 until end of February 2021 to assess the pure effect of the energy community. The data was not in all cases transmitted properly in quarter-hourly time intervals, which led to accumulations of reported zeros as well as high peaks when the data was finally sent. For the analysis, we therefore aggregated the data on daily level and excluded 31 households who had reporting periods of less than 40 days. After this step, a final number of 257 households remained. As a final cleaning step, we dropped observations that were below the 1st percentile or above the 99th percentile of the distribution of the daily electricity consumption data.

In addition to this observational data, we collected sociodemographic characteristics, such as age, gender, and educational level of the respondents. In the pre-intervention survey, we also asked for dwelling characteristics, energy sources, the electric appliance stock, energy literacy and personal attitudes.

In the section on energy literacy, participants were asked to estimate their household's overall electricity consumption, electricity costs and CO_2 emissions associated with electricity consumption. Personal attitudes towards the environment, energy use and social influence were measured on a five-point Likert scale where respondents were asked to what extent they

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[1] For a better comprehension of the following, we will be referring to the 288 core study participants as *study participants*, ignoring those in the separate control group that gave consent to share their data but were not selected for the experimental intervention.

agreed with a given statement. A special focus in our study is on measures that we refer to as *environmental concern* (adopted from Tiefenbeck et al., 2018), *social concern* (adopted from Czibere et al., 2020) and *social identity* (adopted from Allcott and Taubinsky, 2015). The wording of the items used to elicit these measures is shown in Table A1 in the appendix. The measure *environmental concern* is used to represent the participants' general willingness to behave in an environmentally friendly way. The measure *social concern* is used to elicit the perceived environmental concern of people that are important to the participants and thus the participants' perceived social pressure to behave in an environmentally friendly way. Third, the measure *social identity* is collected to represent the participants' general tendencies to behave according to social demand or pressure. We gathered these measures as we believe that they may predict how strongly a person responds to becoming part of an energy community. After the study period, we sent out a second survey to all study participants. Data was collected between 4 June and 24 June 2021. Of all 288 invited households, 222, i.e. 77 per cent, participated also in the second survey. In the post-treatment questionnaire, we collected data on, among others, energy literacy, personal attitudes, general and specific information on web habits and portal usage, personal and estimated efforts of other participants to reduce energy and water usage, experienced social identity as well as attitudes towards energy communities and household characteristics. Furthermore, we gauged the participants' subjective experience and opinions about the study.

We examine the representativeness of the sample by comparing the variables household size, gender, age, income, and education level of the study sample with national statistics from Slovenia in 2019. The average household size of our sample is 3.2 people per household (Table 1), whereas the average household size in Slovenia is 2.5, meaning that larger households are somewhat overrepresented in our study sample. Compared to the general population of Slovenia, our sample is older (52.8 years vs. 44.5 years). The proportion of people with at least a university degree in our sample is very similar to the one in the general Slovenian population, with around 33 per cent in both cases. Males are overrepresented in our sample, where 67.7 per cent of the participants are male, whereas 49.7 per cent of the Slovenian population is male. The average study participant indicated to have a net monthly household income between €1,500 and €2,500, which is similar to the average net monthly household income of €2,060 in Slovenia.

Based on survey and other additional data, a few more characteristics of the study population can be described. An average value of 16.5 out of 20 possible points indicates that the average survey participant is rather concerned about acting environmentally friendly. The values of about 10.9 and 9.0 for social concern and social identity measures (both with a maximum of 15 points) indicate that study participants on average experience a modest feeling of social concern and social identity.

Table 1: Summary statistics

Statistic	Mean	St. Dev.
Age (in years)	52.780	12.537
Household size	3.157	1.303
Female (in %)	0.323	0.468
University degree (in %)	0.327	0.470
Retired (in %)	0.283	0.452
High income (in %)	0.130	0.337
Electric boilers (in %)	0.398	0.490
Floor size (in m²)	111.946	59.797
Heat pump (in %)	0.354	0.479
No. of Fridges	1.429	0.636
No. of Freezers	0.811	0.762
No. of Dish washers	1.055	0.545
No. of Tumble driers	0.642	0.557
Environmental concern	16.492	1.953
Social concern	10.882	1.926
Social identity	9.031	1.731
Mean temperature (°C)	4.371	1.784
No. of logins	4.451	5.657
No. of e-tab	3.440	5.006
Electricity consumption (kWh per day)	18.904	13.685
No. of households	257	

Regarding the use of the online portal, we observed the number of logins and visits of the tab showing electricity use. On average, households logged in into the portal (*No. of logins*) 4.5 times and visited the electricity tab (*No. of e-tab*) 3.4 times during the study period. This implies that the portal is visited less than once a week, which is relatively little (cf., for example, Gerster et al. 2021). The average daily electricity consumption lies at 18.9 kWh. Lastly, the mean temperature, measured at the closest weather station to the respective household, was around 4.5°C for the intervention period.

4.2 Experimental Design

The study began with a baseline period from the beginning of October until 11 December 2020 in which data were collected in the absence of any intervention. At the end of this period, the sample was divided into two groups, the control and the treatment group. This division was conducted randomly, with stratification ensuring that the groups differed as little as possible in terms of their electricity consumption, household size, type of water heating, as well as their environmental attitudes and their tendency to be influenced by their social environment. In Table A2 in the Appendix, we

provide a detailed comparison of the two groups, which provides evidence that the groups do not significantly differ from each other, indicating that the stratified randomization was successful.

To make the setting as comparable as possible for the control and treatment groups, all participants were provided with nudges aiming at reducing the participants' electricity consumption, in particular social comparisons, information provision and norm-based messages, which were implemented via monthly energy reports and a newly designed online platform.[2] On top of these nudges, whose potentials in reducing electricity consumption are already researched in the existing literature (Allcott, 2011; Allcott and Rogers, 2014; Andor et al., 2020c,b; Ferraro et al., 2011; Ferraro and Price, 2013) and which are widely applied by energy utilities, the treatment group received augmented versions of the energy reports and of the online platform. These augmented versions consisted of elements that were intended to increase the motivation to reduce electricity consumption by framing energy conservation as a community effort to the energy community group and to enable social learning by granting the opportunity of communication between the energy community members. These augmentations, which will be described in more detail in the following, and which are summarized in Table 2, represent our main treatment. Originally, it was planned to organize physical meetings among the members of the energy community who all live near or in Ljubljana. Due to the COVID-19 pandemic, physical meetings were not possible during the study period. The community can therefore be characterized as a virtual energy community, in which virtual interactions were possible and stimulated.

Features that were accessible to all study participants (treatment and control group) via the online platform and the monthly energy reports:

- A graphical representation of high-resolution household electricity consumption data over time in 15-minute intervals (see Figure A3 in the Appendix).

- Messages providing tips on how to effectively conserve energy in the household (see Figure A4 in the Appendix).

- A comparison of the weekly average electricity use of the participant's household to the average weekly electricity use of the other study members (calculated based on the control group data). This comparison was accompanied by an injunctive norm message (see for example Schultz et al., 2007) in form of a happy or frowny face that indicates whether the own electricity use was below or above the average electricity use of other study participants.

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[2] Note that GEN-I had already another online platform in place where all customers could access some energy-related information. Specifically, this platform displays monthly electricity consumption with a comparison to respective month in the previous year, electricity prices, invoices, contracts, and information on the metering point. Hence, newly added features include a more detailed temporal comparison of electricity consumption, social comparisons, and more granular data.

Table 2: Overview: Differences between the treatment and the control group

	EC (treatment)	Non EC (control)
Portal access	✔	✔
Data on own electricity & water consumption	✔	✔
Energy saving tips	✔	✔
Monthly comparison of own water and electricity with other study participants	✔	✔
View location of other EC members	✔	✘
Interactive discussion forum	✔	✘
Average electricity consumption of avg EC member compared to avg study participant	✔	✘
Info about the purpose of the platform	EC members have common goal to contribute to more sustainable future by reducing electricity use and thereby lowering electricity bill	platform access to track own energy use

Additional features that were accessible only to the energy community treatment group:

- A message informing that the participant is now a member of a newly created energy community whose common goal is to contribute to a more sustainable future by reducing electricity consumption, thereby also reducing their own electricity bill.

- A comparison of the weekly average electricity use of the treatment group members (referred to as the participant's *energy community*) to the average weekly electricity use of the control group members (referred to as the *other study participants*). Again, this comparison was accompanied by an injunctive norm message (Schultz et al., 2007) in form of a happy or frowny face that indicates whether the treatment group's electricity use was below or above the control group's electricity use (see Figure A5 in the Appendix).

- A moderated interactive discussion forum where participants could share advice on saving energy at home, motivate each other to increase conservation efforts, and also discuss off-topic content. GEN-I moderated this forum by posting public polls on various energy-related topics, asking general questions to stimulate discussion among participants, and providing opportunities to comment on the energy saving tips (see Figure A6 in the Appendix).

- A map displaying the location of the other treatment group members, intended to emphasize that the participants are connected by being from a similar area (see Figure A5 in the Appendix).

4.3 Power Analysis

Prior to running the experiment, we investigated the statistical power of our experiment based on prior work by Degen et al. (2013) and Gerster et al. (2021) who investigated the effects of electricity consumption feedback in similar field experimental settings.

Assuming a sample size of 300 households and standard errors ranging from 0.11 to 0.22 kWh per day, we calculated minimum detectable effects (MDE) of 0.31–0.59 kWh per day (in our setting, this corresponds to 1.60–3.05% of the average electricity use of the control group in the treatment period). For the effect of the energy community there is no prior evidence in the literature to compare these MDEs to. To provide some intuition nevertheless, we presented an indicative cost-benefit calculation in our pre-analysis plan (see Andor et al., 2020a for details). Based on this cost-benefit analysis, which incorporates the labour cost to maintain the energy community on the cost side and the conserved social cost of carbon on the benefit side, we argue in our pre-analysis plan that the MDEs provide us with enough statistical power to be able to estimate economically meaningful effect sizes. Even though our final sample is somewhat smaller than has been expected prior to the study and the standard errors of our treatment effects are larger than the ones in our reference papers, the main conclusions from this cost-benefit analysis hold for our final sample.

5 Results

5.1 Average treatment effect

The main outcome of our analysis is daily electricity consumption. Figure 1 illustrates the consumption patterns across the two experimental conditions. We observe that consumption increases drasticallyfrom the beginning of October until the beginning of December. As roughly a quarter of the respondents uses electrical energy or a heat pump for space heating (some households use the heat pump for warm water only), this increase in consumption is likely to be due to the start of the heating period (see also Figure A1 in the Appendix for the correlation of temperature with electricity consumption).

Another factor that may be responsible for this sharp increase as well as the particular form of the curves is the lockdown situation in Slovenia as well as the holiday season around Christmas.[3] For both treatment and control group,

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[3] Massive restrictions, particularly with regards to travel and assembly options occurred between 19 October 2020 to 9 February 2021 with relaxations of those for Christmas and New Year's Eve.

electricity consumption exhibits similar trends over the entire observation period. For the control group, a slightly lower consumption can be observed. The implementation of the energy community on December 11 seems to have no particular effect on the treatment group. From January onward, electricity consumption in both groups declines again.
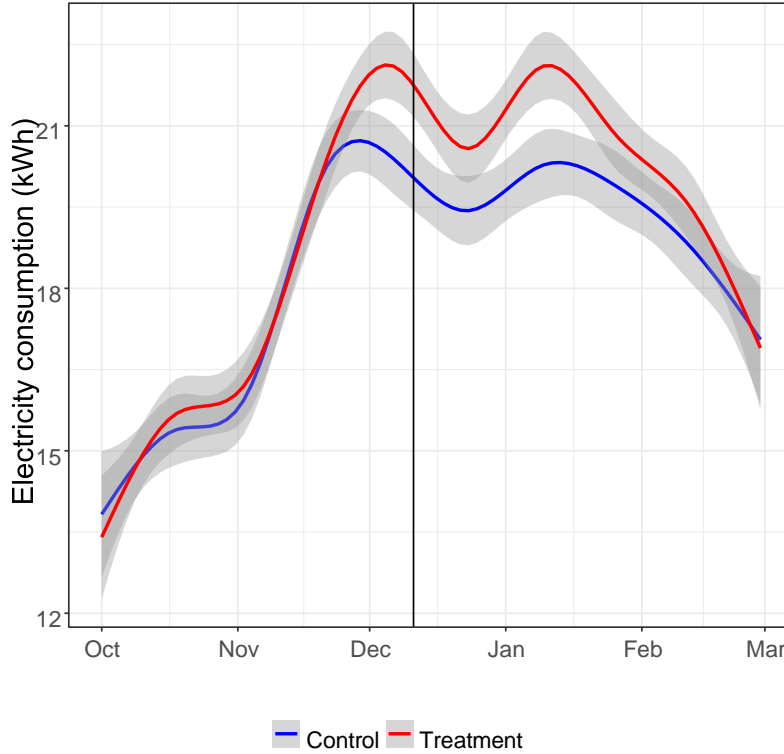
Figure 1: Electricity consumption across experimental conditions

The focus of our analysis is whether the implementation of the energy community has led to different consumption patterns between the treatment and the control group. To this end, we conduct a standard difference-in-differences analysis:

$$Y_{it} = \alpha + \beta Post_{it} + \delta(Treat_{it} \times Post_{it}) + \theta_i + v_t + \varepsilon_{it},$$

where Y_{it} denotes the electricity consumption (C) of household i on day t compared to the average daily consumption of the control group in the treatment period ($\bar{C}_e^c$) i.e. $Y_{it} = \frac{C_{it} - \bar{C}_e^c}{\bar{C}_e^c}$.

The vector $Post_{it}$ denotes the time period after starting the energy community and $Treat_{it}$ denotes belonging to the treatment group. Fixed effects are included to capture day-specific (v_t) and households-specific effects (θ_i). α, β, and δ are parameters to be estimated and ε_{it} is an error term.

Our main interest is the interaction term $Treat_{it} \times Post_{it}$ and its parameter δ. We cluster the standard errors at the household level (Bertrand et al., 2004).

Our main results are reported in Table 3 where we trim the dependent variable at the 1% and 99% percentile.[4] Our empirical estimation sustains the graphical illustration from Figure 1 that consumption after the implementation of the energy community in mid-December is higher in both experimental groups as indicated by the $Post$ dummy. The interaction term $Treat \times Post$ is small in magnitude and statistically insignificantly different from zero. Hence, the implementation of our energy community did not have a differential effect compared to the control group.

The virtue of the fixed-effects estimator is that it implicitly controls for all time invariant characteristics, such as income, household size, etc. Furthermore, the day-specific fixed effect implicitly controls for time varying variables that affect all participants uniformly. One example is outdoor temperature, which exhibits little cross-sectional variation among the study participants because of their regional proximity. When we omit the day-specific fixed effects but instead control for the daily outdoor temperature, as displayed in Column (2) in Table 3, the estimate of the treatment effect, i.e., the interaction term $Treat_{it} \times Post_{it}$, remains virtually unchanged, while a strongly negative effect of an increase in the outside temperature on electricity emerges, indicating that a 1-degree Celsius increase in the average outdoor temperature is on average associated with a decrease in electricity consumption by 2.5 per cent. This shows that the outside temperature is in fact a very strong predictor of electricity use over time, as was indicated by inspection of the temperature and electricity consumption time series displayed in Figure A1 in the Appendix.

One alternative way to estimate the difference-in-differences model is to omit also the individual fixed-effects and instead control additionally for observable characteristics and a binary dummy variable that indicates the membership in the energy community ($Treat$). This model can be estimated using the Ordinary Least Squares (OLS) method. The dummy variable $Treat$ in Column (3) in Table 3 shows that difference in baseline consumption between the treatment and the control group is not statistically significant from zero, corroborating the graphical results from Figure 1. The point estimate of the interaction term $Treat \times Post$ is even somewhat smaller in magnitude compared to specifications (1) and (2) and it is also not statistically different from zero. Moreover, the OLS model shows that, in addition to the outdoor temperature, the household size and the equipment with a heat pump are predictive of electricity consumption.

In Column (4), we furthermore control for the average electricity use in the baseline period. We find that the coefficients on household size and the

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[4] As robustness checks, we present the difference-in-differences estimation results when the dependent variable is measured in kWh (Table A3 in the Appendix). In addition, we trim the dependent variable in different manners. The trimming procedures and results are documented in Table A4. Overall, the main conclusions remain unchanged.

equipment with a heat pump shrink substantially compared to Column (3), which is likely due to the high collinearity between these characteristics and the electricity use in the baseline period. Instead, the coefficient indicating that the study participant has a university degree increases and becomes statistically significant in Column (4). One potential reason for this could be that university graduates generally have more opportunities to work from home and have done so during the pandemic-related restrictions in the winter of 2020/2021.

Table 3: Difference-in-differences estimation results

	(1) Coeff.	(1) Std. Err.	(2) Coeff.	(2) Std. Err.	(3) Coeff.	(3) Std. Err.	(4) Coeff.	(4) Std. Err.
Treat	–	–	–	–	-0.003	(0.062)	0.004	(0.015)
Post	0.360**	(0.041)	0.022	(0.021)	0.026	(0.026)	0.046	(0.023)
Treat × Post	0.018	(0.034)	0.018	(0.034)	0.007	(0.036)	0.003	(0.035)
Average temperature	–	–	-0.025**	(0.003)	-0.025**	(0.003)	-0.022**	(0.002)
Age	–	–	–	–	0.006	(0.004)	0.000	(0.001)
Household size=2	–	–	–	–	0.210*	(0.091)	0.002	(0.020)
Household size=3	–	–	–	–	0.623**	(0.105)	0.003	(0.021)
Household size=4	–	–	–	–	0.501**	(0.114)	-0.016	(0.023)
Household size=5	–	–	–	–	0.746**	(0.107)	-0.016	(0.025)
Female	–	–	–	–	0.062	(0.078)	-0.006	(0.016)
University	–	–	–	–	0.044	(0.075)	0.055**	(0.015)
Retired	–	–	–	–	-0.118	(0.142)	0.010	(0.026)
High income	–	–	–	–	-0.072	(0.127)	-0.021	(0.018)
Heat pump	–	–	–	–	0.662**	(0.087)	0.063**	(0.019)
Baseline consumption	–	–	–	–	–	–	0.059**	(0.001)
Constant	-0.359**	(0.030)	-0.064**	(0.011)	-0.941**	(0.238)	-1.035**	(0.045)
Day fixed effects	Yes		No		No		No	
Individual fixed effects	Yes		Yes		Yes		Yes	
No. of observations	37,528		37,528		35,229		35,229	
No. of households	257		257		240		240	

Note: Standard errors are clustered at the household level and reported in parentheses. For the analysis, we drop the 1% and 99% percentile of our dependent variable. ** and * denote statistical significance at the 1 % and 5 %, level, respectively. The outcome variable (Y_{it}) is defined as the percentage deviation of daily electricity consumption (C_{it}) from the average daily electricity consumption of the control group in the treatment period ($\bar{C}_{\bar{e}}^c$ = 19.358 kWh), i.e. $Y_{it} = \frac{C_{it} - \bar{C}_{\bar{e}}^c}{\bar{C}_{\bar{e}}^c}$.

5.2 Heterogeneous treatment effects

Next, we delve deeper into the analysis and show the treatment effects for different time periods and conduct a heterogeneity analysis using the fixed-effects estimator. For the first endeavour, we restrict the sample to only one treatment month, which is either (1) January or (2) February. Regarding the heterogeneity analysis, we augment our empirical model with the interaction terms between the variables of interest with the *Post* dummy and its interaction with the *Treat* dummy.

We find that our treatment does not have differential effects across the different treatment months (Table 4). To analyse whether the treatment effect differs according to the participants' personal attitudes, we focus on three measures elicited in the pre-intervention survey and described in Section 4.1: *Environmental concern*, *social concern,* and *social identity*. As depicted in Table 5, we do not find significant differences in the treatment effects according to these attitudinal variables.

Table 4: Difference-in-differences estimation results for different time periods

	January		February	
	Coeff.	Std. Err.	Coeff.	Std. Err.
Post	0.572**	(0.055)	0.362**	(0.040)
Treat × Post	0.029	(0.040)	0.014	(0.028)
Constant	-0.358**	(0.030)	-0.353**	(0.027)
Day fixed effects	Yes		Yes	
Individual fixed effects	Yes		Yes	
No. of observations	30,627		29,891	
No. of households	257		257	

Note: Standard errors are clustered at the household level and reported in parentheses. For the analysis, we drop the 1% and 99% percentile of our dependent variable. ** and * denote statistical significance at the 1 % and 5 %, level, respectively. The outcome variable (Y_{it}) is defined as the percentage deviation of daily electricity consumption (C_{it}) from the average daily electricity consumption of the control group in the treatment period ($\bar{C}_e^c$ = 19.358 kWh), i.e. $Y_{it} = \frac{C_{it} - \bar{C}_e^c}{\bar{C}_e^c}$.

In Table 6, we furthermore investigate whether our treatment has differential effects with regard to further potential sources of heterogeneity, namely baseline electricity use, the number of logins on the virtual portal, and the subjective experience with participating in the study, as reported in the survey conducted at the end of the study. Yet, the treatment effects do not significantly differ according to these variables.

Table 5: Heterogeneous treatment effects for personal attitudes

	(1) Coeff.	(1) Std. Err.	(2) Coeff.	(2) Std. Err.	(3) Coeff.	(3) Std. Err
Post	0.357**	(0.041)	0.360**	(0.041)	0.360**	(0.041)
Treat × Post	0.016	(0.035)	0.012	(0.034)	0.013	(0.034)
Post × Env. concern	-0.029	(0.030)	–	–	–	–
Treat × Post × Env. concern	0.009	(0.038)	–	–	–	–
Post × Soc. concern	–	–	0.031	(0.025)	–	–
Treat × Post × Soc. concern	–	–	-0.014	(0.032)	–	–
Post × Soc. identity	–	–	–	–	0.008	(0.024)
Treat × Post × Soc. identity	–	–	–	–	0.048	(0.029)
Constant	-0.359**	(0.030)	-0.359**	(0.030)	-0.359**	(0.030)
Day fixed effects	Yes		Yes		Yes	
Individual fixed effects	Yes		Yes		Yes	
No. of observations	37,265		37,265		37,265	
No. of households	254		254		254	

Note: Standard errors are clustered at the household level and reported in parentheses. For the analysis, we drop the 1% and 99% percentile of our dependent variable. ** and * denote statistical significance at the 1 % and 5 %, level, respectively. The outcome variable (Y_{it}) is defined as the percentage deviation of daily electricity consumption (C_{it}) from the average daily electricity consumption of the control group in the treatment period ($\bar{C}_{\tilde{e}}^c$ = 19.358 kWh), i.e. $Y_{it} = \frac{C_{it} - \bar{C}_{\tilde{e}}^c}{\bar{C}_{\tilde{e}}^c}$.

Table 6: Heterogeneous treatment effects for other attributes

	(1) Coeff.	(1) Std. Err.	(2) Coeff.	(2) Std. Err.	(3) Coeff.	(3) Std. Err
Post	0.045	(0.039)	0.324**	(0.044)	0.327**	(0.046)
Treat × Post	0.067	(0.039)	0.065	(0.043)	0.034	(0.045)
Post × Baseline consumption	0.018**	(0.002)	–	–	–	–
Treat × Post × Baseline consumption	-0.003	(0.003)	–	–	–	–
Post × No. logins	–	–	0.009	(0.005)	–	–
Treat × Post × No. logins	–	–	-0.011	(0.006)	–	–
Post × Study experience	–	–	–	–	0.029	(0.061)
Treat × Post × Study experience	–	–	–	–	-0.044	(0.080)
Constant	-0.355**	(0.026)	-0.359**	(0.030)	-0.370**	(0.034)
Day fixed effects	Yes		Yes		Yes	
Individual fixed effects	Yes		Yes		Yes	
No. of observations	37,455		37,528		28,841	
No. of households	256		257		197	

Note: Standard errors are clustered at the household level and reported in parentheses. For the analysis, we drop the 1% and 99% percentile of our dependent variable. ** and * denote statistical significance at the 1 % and 5 %, level, respectively. The outcome variable (Y_{it}) is defined as the percentage deviation of daily electricity consumption (C_{it}) from the average daily electricity consumption of the control group in the treatment period ($\bar{C}_{\tilde{e}}^c$ = 19.358 kWh), i.e. $Y_{it} = \frac{C_{it} - \bar{C}_{\tilde{e}}^c}{\bar{C}_{\tilde{e}}^c}$.

6 Conclusion

The aim of this study was to analyse the potential of top-down exogenously created energy communities and their impact on energy conservation behaviour. To this end, we implemented a randomized controlled field experiment in collaboration with the largest Slovenian electricity supplier, GEN-I, and co-created the *GEN-I Energy Community.* GEN-I asked around 10,000 of their customers if they would like to take part in a research study. Of the more than 1,000 customers who were willing to participate, we chose 300 customers to be part of the core study. Of these 300, half of the participants were randomly assigned to the newly developed energy community. It is therefore a top-down energy community that could in principle be set up in a similar way by any energy utility in Europe.

The *GEN-I Energy Community* received monthly newsletters with energy saving tips, testimonials, comparison reports of electricity use within and outside the community, and members had access to an interactive virtual portal. To identify the pure community effect and not the effect of a treatment that comprised a multitude of different elements (cf. Andor and Fels, 2018), among others a variety of information and different nudges, we gave the control group the same information and nudges, except for the community elements. All participants gave consent to share their smart meter electricity data during the intervention. Two surveys, one before and one after the intervention, were conducted among all participating households to complement the electricity data with information about the socio-economic background, living conditions, appliances used as well as personal attitudes and behaviours.

Our results suggest that the membership in the *GEN-I Energy Community* had not a considerable energy conservation effect. Such an average null effect may be caused by the fact that there is actually no effect or that effects for different groups cancel each other out. We therefore conducted several heterogeneity analyses regarding, for instance, baseline consumption, environmental concern, social concern and social identity. In all heterogeneity analyses, we could not find any subgroup for which a saving effect was detected. One possible explanation is that group identity among community members did not evolve as expected in our setting.

Our results illustrate that initiating energy communities top down is difficult. Grassroot energy communities have the advantage that only self-motivated members are active. Yet, it is not clear if such models can scale up to a meaningful contribution for the energy transition. Top-down energy communities could be easier to scale, however, it is unclear if or how exogenous assigned members can be motivated to really act in the community and develop a group identity.

Yet, our study is only a first step in this research line. We see several possibilities why energy communities in general and also such top-down energy communities can be successful in general and with regard to energy conservation despite our results so far. First, in Deliverable 5.2, we will investigate the longer-term effects and in particular the interaction effects of

membership in the *GEN-I Energy Community* with behavioural interventions. Extensive literature has shown the effectiveness of behavioural interventions on stimulating electricity conservation (e.g. Andor and Fels, 2018; Buckley, 2020). While these interventions usually focus on regular customers of energy suppliers, to our best knowledge, they have not been applied in the context of clean energy communities so far. Thus, while we find that membership in the *GEN-I Energy Community* alone does not cause a conservation effect, membership might increase the effect of behavioural interventions.

Second, in this present study we only observe a period of five months. It might be that it may take longer to initiate an energy community, e.g. to build trust, explore options and establish social contacts in the community. Third, there is a growing literature providing evidence that causal effects measured in a particular study population and set-up depend on the particular context and the implementation partner (e.g. Allcott, 2015; Andor et al., 2020b; Dehejia et al., 2021; Peters et al., 2018; Vivalt, 2020). Based on her finding that generalizability between different programs and settings is often limited for many types of interventions, Vivalt (2020) recommends conducting impact evaluations in multiple settings with varying contexts. These arguments seem particularly appropriate in the context of energy communities, which are generally so diverse. In addition, it could be that the location and the time mattered. In comparison to, for example, most German electricity customers, Slovenians receive their electricity bill more frequently (monthly vs. yearly), with all the side effects, such as salience of energy costs and feedback on the consumption. The GEN-I customers even already had a virtual portal showing not all but some of the information the *GEN-I Energy Community* portal offered. In terms of time, the COVID-19 pandemic is certainly very special. Due to the pandemic, the implementation of physical meetings was not possible during our study period. This could be a central reason why identity with the community and interactions were rather low. Other aspects are more difficult to assess. For example, it is not clear whether the lockdowns meant that people had time to think about energy-saving options because they had to stay home anyway. Or whether it was particularly difficult to get people to think about energy conservation during this time because they were experiencing extraordinary stress in their daily lives. . In conclusion, we therefore see our findings as the beginning of a research stream that explores the potential for initiating energy communities and properly assesses the impact of community membership on energy conservation.

7 ANNEX

A Tables and Figures

Table A1: Scales used to measure environmental, social concern and social identity

Question	Scaling Adjustments
Environmental concern I am willing to act environmentally responsible, even if this is associated with higher costs and efforts. (Tiefenbeck et al., 2018) I am willing to act environmentally responsible only if others do the same. I would act according to my principles if I save energy. (Czibere et al., 2020) I feel personally responsible for trying to save energy. (Czibere et al., 2020)	reverse coding
Social concern (Czibere et al., 2020) Most of the people who are important to me think I should try to use as little energy as possible. Most of the people who are important to me will approve of when I try to use as little energy as possible. Most people who are important to me try to use as little energy as possible.	
Social identity (Allcott and Taubinsky, 2015) It's important for me to fit in with the group I'm with. My behaviour often depends on how I feel others wish me to behave. I would NOT change opinions (or the way I do things) in order to please someone else or win their favour.	reverse coding

Respondents could answer these questions on a five-point Likert scale, ranging from 'I strongly disagree' to 'I strongly agree'. The nature of some questions made it necessary to rescale the answers before combining them into one measure to ensure coherence. This is indicated by 'reverse coding'.

Table A2: Summary statistics - comparison between the treatment and control group

	Control	Treatment	t-Statistic
Age	53.322	52.260	0.655
Household size	3.173	3.142	0.192
Female	0.299	0.346	-0.803
University degree	0.307	0.346	-0.667
Retired	0.307	0.260	0.833
High income	0.118	0.142	-0.558
Electric boilers	0.433	0.362	1.152
Floor size	114.390	109.483	0.647
Heat pump	0.362	0.346	0.261
Fridges	1.449	1.409	0.493
Freezers	0.819	0.803	0.164
Dish washers	1.039	1.071	-0.460
Tumble driers	0.677	0.606	1.015
Environmental concern	16.307	16.677	-1.513
Social concern	10.929	10.835	0.390
Social identity	9.071	8.992	0.362
Mean temperature	4.339	4.403	-0.287
No. of logins	4.271	4.633	-0.511
No. of e-tab	3.186	3.695	-0.814
Electricity consumption	18.772	19.037	-0.155
No. of households	129	128	–

Table A3: Difference-in-differences estimation results when the dependent variable is measured in kWh

|	(1)		(2)		(3)		(4)	
	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.
Treat	–	–	–	–	0.076	(0.282)	0.076	(0.282)
Post	6.975**	(0.794)	0.425	(0.412)	0.884	(0.455)	0.884	(0.455)
Treat × Post	0.342	(0.658)	0.339	(0.659)	0.056	(0.686)	0.056	(0.686)
Average temperature	–	–	-0.482**	(0.049)	-0.428**	(0.047)	-0.428**	(0.047)
Age	–	–	–	–	0.007	(0.016)	0.007	(0.016)
Household size=2	–	–	–	–	0.043	(0.390)	0.043	(0.390)
Household size=3	–	–	–	–	0.057	(0.411)	0.057	(0.411)
Household size=4	–	–	–	–	-0.310	(0.436)	-0.310	(0.436)
Household size=5	–	–	–	–	-0.308	(0.493)	-0.308	(0.493)
Female	–	–	–	–	-0.112	(0.307)	-0.112	(0.307)
University	–	–	–	–	1.071**	(0.299)	1.071**	(0.299)
Retired	–	–	–	–	0.186	(0.497)	0.186	(0.497)
High income	–	–	–	–	-0.401	(0.354)	-0.401	(0.354)
Heat pump	–	–	–	–	1.218**	(0.366)	1.218**	(0.366)
Baseline consumption	–	–	–	–	1.138**	(0.018)	1.138**	(0.018)
Constant	12.415**	(0.586)	20.602**	(0.206)	-0.672	(0.878)	-0.672	(0.878)
Day fixed effects	Yes		No		No		No	
Individual fixed effects	Yes		Yes		Yes		Yes	
No. of observations	37,528		37,528		35,229		35,229	
No. of households	257		257		240		240	

Note: Standard errors are clustered at the household level and reported in parentheses. For the analysis, we drop the 1% and 99% percentile of our dependent variable. ** and * denote statistical significance at the 1 % and 5 %, level, respectively.

**Table A4:** Difference-in-differences estimation results for different data cleaning procedures

	(1)		(2)	
	Coeff.	Std. Err.	Coeff.	Std. Err.
Post	0.154**	(0.023)	0.111**	(0.023)
Treat × Post	0.022	(0.016)	0.006	(0.018)
Constant	-0.070**	(0.015)	-0.086**	(0.015)
Individual fixed effects	Yes		Yes	
Day fixed effects	Yes		Yes	
No. of observations	34,581		24,801	
No. of households	256		165	

Note: Standard errors are clustered at the household level and reported in parentheses. In Column (1), we trim the 5% and 95% percentile of the dependent variable. Column (2) dismisses all households whose daily mean consumption in the post-treatment period is more than 100% below or 100% above the daily mean consumption in the baseline period. ** and * denote statistical significance at the 1 % and 5 % level, respectively.
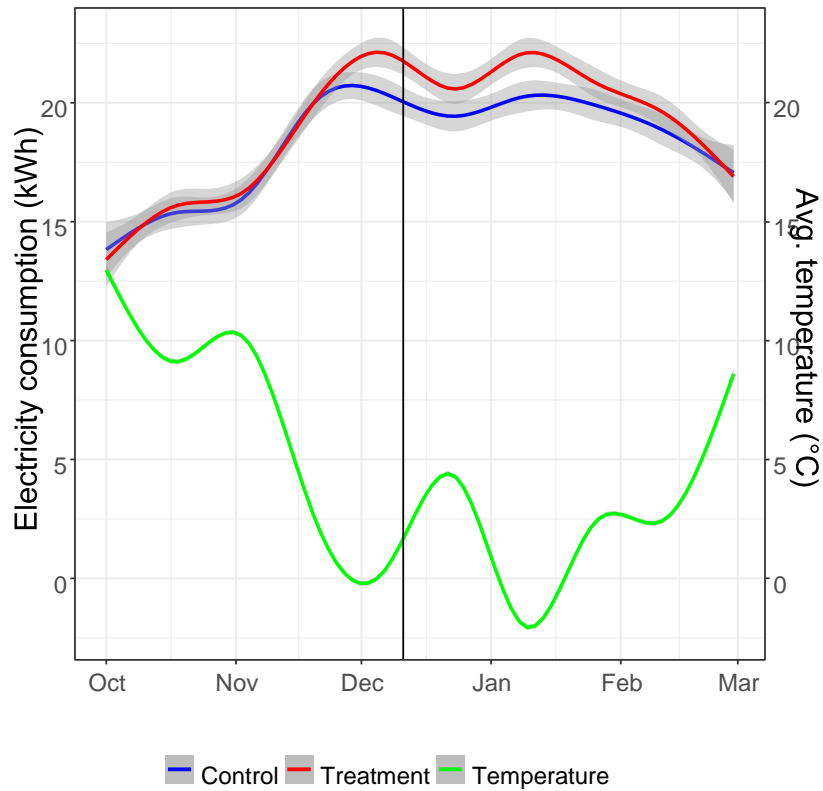
Figure A1: Electricity consumption across experimental conditions and temperature
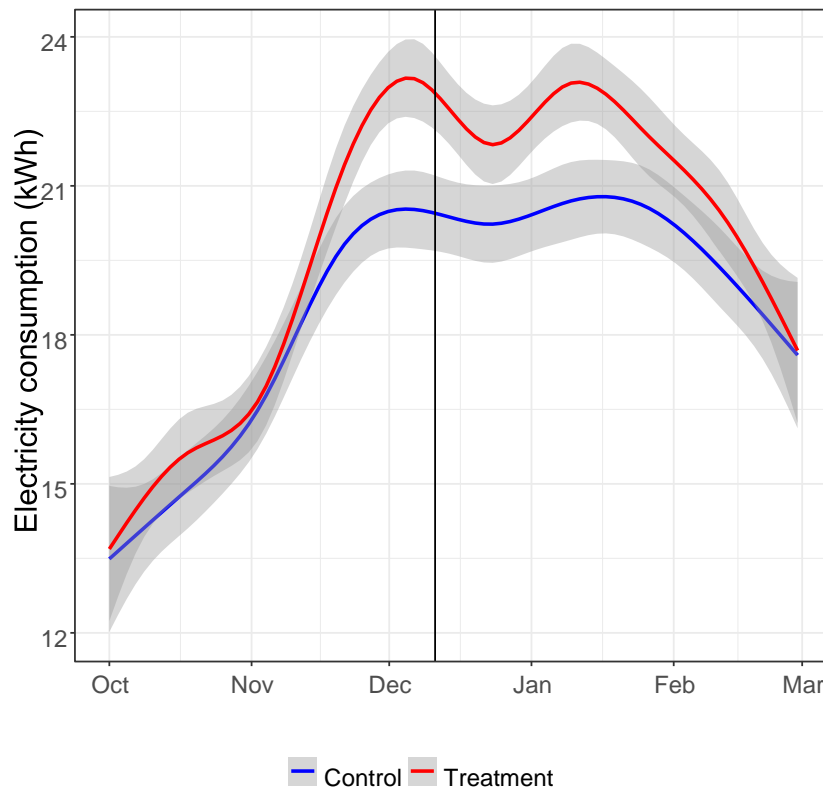
Figure A2: Electricity consumption across experimental conditions for households that do not heat with electricity

B   Background on the experiment
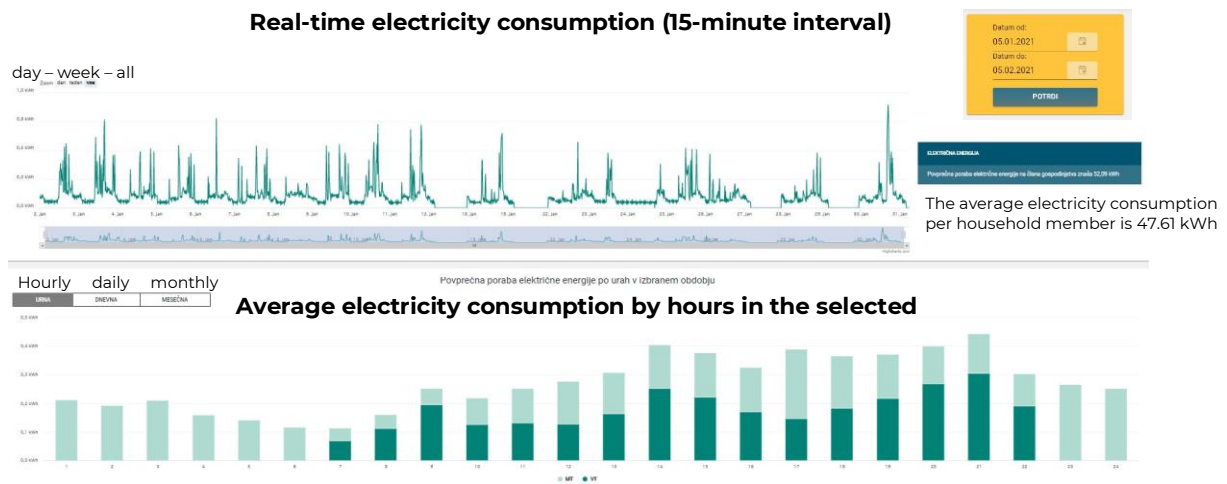
Figure A3: Electricity consumption shown on the virtual platform to all study participants.

Practical tips for saving energy in January

We have entered the new year 2021, which we all wish will be positive. In the winter months, when the temperatures outside are not at all tempting, we will spend more time indoors, in the warmth. But the comfort of warm radiators can quickly be overshadowed by high heating costs, which we often have, whether we admit it or not. At least in part. We want to share some practical tips on how to ensure a comfortable stay and at the same time save on energy consumption.

✔ Lower the temperature of your heating by one degree. By doing so, your heating costs will be up to 6 per cent lower. Plus, you'll have a great excuse to re-wear your Christmas sweater.

✔ Lower the room temperature to 15 ° C at night. You can do this on the eve of bedtime.

✔ Your appliances (washing machine, dishwasher, dryer) should operate during the time of lower electricity tariffs, between 10 pm and 6 am By using the devices at night, you will help to reduce the load on the electricity network during higher daily tariff items, which are charged every working day between 6 am and 10 pm.
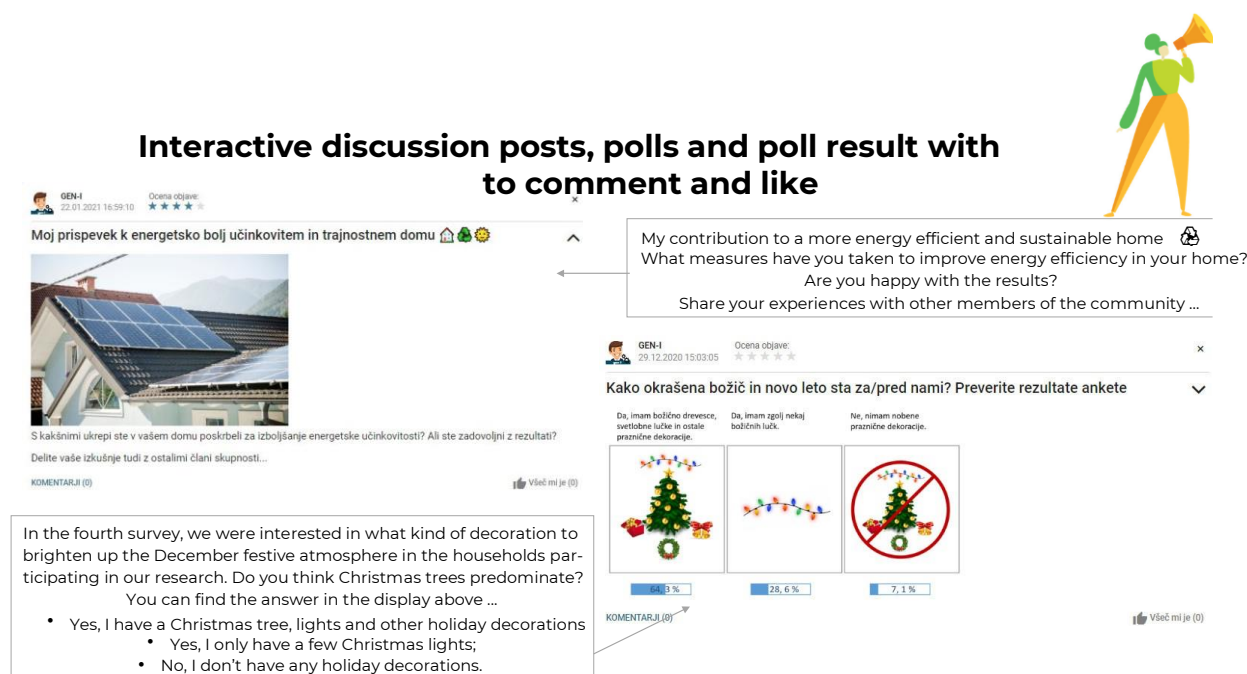
Comments (0)
Like (1)

Figure A4: Energy saving tips shown on the virtual platform to all study participants.
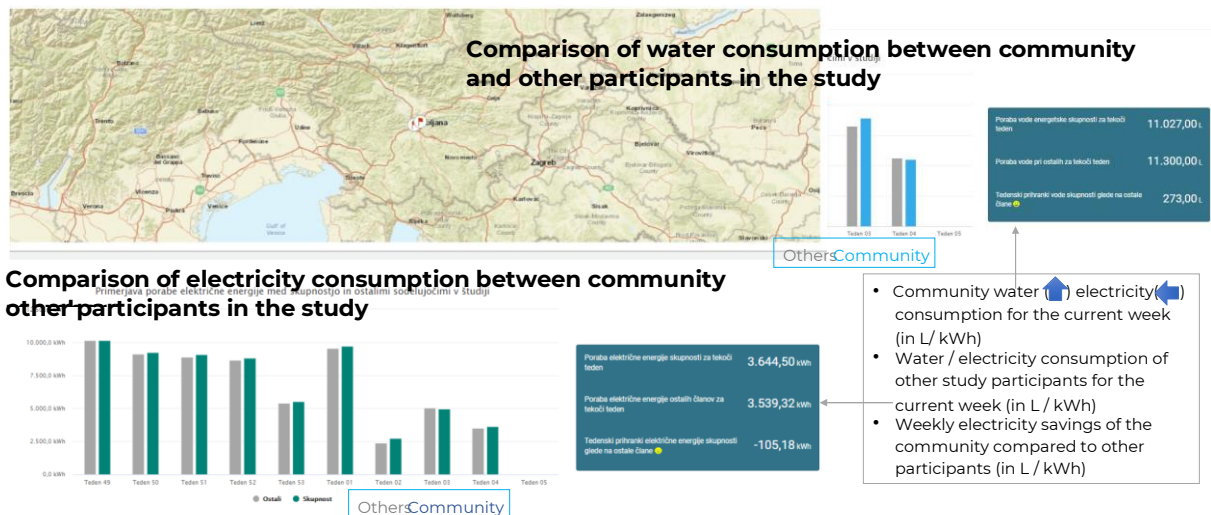
Figure A5: Features of the virtual platform for *GEN-I Energy Community* members only.

**Interactive discussion posts, polls and poll result with
to comment and like**

My contribution to a more energy efficient and sustainable home ♻
What measures have you taken to improve energy efficiency in your home?
Are you happy with the results?
Share your experiences with other members of the community …

In the fourth survey, we were interested in what kind of decoration to brighten up the December festive atmosphere in the households participating in our research. Do you think Christmas trees predominate? You can find the answer in the display above …

- Yes, I have a Christmas tree, lights and other holiday decorations
- Yes, I only have a few Christmas lights;
- No, I don't have any holiday decorations.

Figure A6: Screenshot of the interactive discussion forum on the virtual platform for *GEN-I Energy Community* members only.

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