Project no.:	**101022587**
Project full title:	**Sustainable energy system for achieving novel carbon neutral energy communities**
Project Acronym:	**SUSTENANCE**

Deliverable number:	**D3.5**
Deliverable title:	**Categorization of types of consumers**
Work package:	WP3
Due date of deliverable:	M24
Actual submission date:	M27 - 30/06/2023
Start date of project:	01/07/2021
Duration:	42 months
Reviewer(s):	Morten Veis Donnerup (NEOGRID), Manohar Yadav (MNNIT)
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Contributing partners:	UT, NEOGRID, MNNIT

Dissemination level of this deliverable	**PU**
Nature of deliverable	R

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101022587, and the Department of Science and Technology (DST), Government of India under the SUSTENANCE project. Any results of this project reflect only this consortium's view and the funding agencies and the European Commission are not responsible for any use that may be made of the information it contains.

Document history

Version no.	Date	Authors	Changes
0.1	16-06-2023	Ewert Aukes, Imad Ibrahim, Lisa Sanderink, Yoram Krozer, Frans Coenen (UT)	First draft
0.2	25-6-2023	Morten Veis Donnerup (NEOGRID), Manohar Yadav (MNNIT)	Review comments
1.0	30-06-2023	Ewert Aukes, Imad Ibrahim, Lisa Sanderink, Yoram Krozer, Frans Coenen (UT)	Final version

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Table of Contents

List of figures

Executive Summary

Not least due to the conflict in Ukraine, energy security, energy independence, and energy decentralisation have moved more and more centre stage in recent years. As a complex process, the energy transition is characterised by various factors impacting its direction, speed, and success. An idea that has some resonance in literature as well as in practice is that of the social acceptability of energy autarky, i.e. the deliberate organisation of local energy systems such that they can produce, transmit, and consume energy (mostly electrical) in a self-sufficient manner. This is a core interest of the social-scientific work packages in the SUSTENANCE project and will be further detailed in this report. We ask:

- How is social acceptability of the local energy transition in its various facets represented in energy autarky?
- Which types of consumers can be discerned in relation to energy autarky?

Relying on ten dimensions that together constitute configuration of energy autarky for a particular locale (cf. SUSTENANCE deliverable 3.3), we explore the data generated by a survey administered in the regions accommodating the three SUSTENANCE demonstrator sites: Skanderborg (DK), Gdansk (PL), and Olst-Wijhe (NL). Based on the answers provided in this survey, we discuss patterns and compare them as far as the low sample sizes allow, for now. In turn, this leads to a characterisation of the types of consumers per municipality. We also provide an outlook on the Indian consumers, as required within SUSTENANCE, but have not been able to administer the survey there (section 3.3).

Based on the results of the survey, it seems that citizens embrace the concept of energy autarky albeit implicitly at the local level to a certain extent since it provides them with the capability to have a say but also be energy independent. Respondents in our sub-samples seemed more reluctant to deal with the governance that would come along with *really* doing everything autarkically. Nevertheless, the general direction is towards energy generation and consumption at the local level where exchanges among communities would take place when in need. We also find that further efforts are needed at various levels to ensure that citizens are aware of the impact their behaviour has on the energy transition. Overall, the social acceptability of energy autarky is connected to citizens' need to be energy independent. It is important to mention here that this result can only be seen in the European context and not generalized elsewhere especially in developing countries.

In the preliminary, exploratory data analysis, we have also distinguished the profiles of consumers in the three sub-samples. The individual sub-samples are not yet large enough for assuming representativity, so we present images of consumer types that may still be subject to change. We observe differences in the types of homes the respondents own and their income. But within their sub-samples, there seems to be an alignment of energy values, which we suggest as a factor in allowing for higher social cohesion in terms of energy. Although saving money by transforming the local energy system can definitely be considered a driver for all three consumer types, there are also indications that environmental considerations play some role in decisions. Further details, including similarities and differences can be found in Section 5.2.

Amongst more detailed conclusions (Section 6), we observe that social acceptability of energy autarky is present. The types of consumers in our survey sub-samples have partly differing motivations to engage in energy autarky activities.

1 Introduction

Energy decentralization in general and energy autarky specifically have been examined in recent years not least due to the Russian-Ukrainian conflict that led to a global increase in oil and gas prices. This situation has invigorated the pre-existing focus on local production and use. However, to reach this objective, great efforts are needed at different levels including households, neighborhood, and municipal ones, as each of these impacts the energy transition in its own way. Firstly, the energy transition is not a straightforward process as many factors must be considered. These include the amount of time needed and the way sustainable energy technologies can be scaled up and disseminated successfully (Grubler, 2012). Still, this phenomenon is slowly taking place globally considering the various actors that are relevant mainly industries, consumers, and governments (Genc & Kosempel, 2023). Based on this, one can already notice for instance that renewable energy is progressively increasing in Europe due to various states policies (Wierling et al., 2018). Some even speak of the next phase of energy transition where established energy business models would slowly fade while the struggle of economic and political actors will intensify (Markard, 2018). It remains to be seen whether this will take place creating a new reality at the local, national and international level (Griffiths, 2019). Given this, policymakers, researchers, and political leaders are pushing towards further sustainable energy via investments, research (Butschek et al., 2023), and financial capital (Best, 2017). Still, further work is needed, especially when it comes to research.

This report falls under this framework where the local energy transition is discussed from an energy autarky perspective. It addresses the following questions:

- How is social acceptability of the local energy transition in its various facets represented in energy autarky?
- Which types of consumers can be discerned in relation to energy autarky?

Energy autarky is defined as a situation where renewable energy is being produced locally to provide energy services for various purposes. This also includes local energy consumption. Its success relies on several factors mainly enhancing energy efficiency, achieving the needed energy transition and the establishment of a decentralized energy system. Various actors play a role. These are administrations at the national, municipal, and local level and civil society organizations to ensure acceptance of such a transition from citizens. The end goal is communities' complete reliance on its energy resources although exchanges between them and regions will likely occur. Hence, energy autarky should not be seen as a call for isolation (Müller et al., 2011). Its main elements are the following: "1) use of endogenous potentials for renewable energy resources rather than energy imports; 2) decentralization of the energy system and 3) increases in the energy efficiency of the supply and the demand side" (Müller et al., 2011, p. 5802). This concept is being examined and implemented for instance at the municipality and households' level (Woch et al., 2014; Brosig & Waffenschmidt, 2016). Based on this, some are even studying the possibility for having renewable electricity autarky at all levels in Europe (Tröndle, Pfenninger & Lilliestam, 2019). Still, the concept itself is still developing and its boundaries enlarged depending on the context and interpretation provided to the term (Deutschle et al., 2015), where politics among many other things play an important role (Nance & Boettcher III, 2017).

The report analyzes ten different dimensions in relation to energy autarky at the community level. These were established in previous SUSTENANCE deliverables (i.e. deliverables 3.1-3.3). These are: 1) alignment of energy values; 2) formal self-governance; 3) energy and land regulations; 4) social organizations; 5) technological dependency; 6) local renewable energy sources; 7) settlement characteristics; 8) building characteristics; 9) complexity of energy uses and 10) scope of autarky. Each dimension is described and embedded in its scientific literature context (Section 3). Then, based on the responses to a survey, where questions related to these ten categories were made, we attempt to understand current citizens and communities' attitude towards energy autarky (Section 4). We provide a preliminary understanding of the links between social acceptability and energy autarky as understood by SUSTENANCE (Section 5). We conclude with an outlook on further work in general and within the project (Section 6).

It is worth mentioning the limitations of the report right off the bat. First, the sample for now only allows preliminary exploration of the data. Rather, we have added the likelihood that a specific outcome might occur based on the result of the survey. Overall, on that basis, one can argue that citizens in Poland, Denmark and the Netherlands are aware of the need of having energy transition and support it. They also prefer energy generation at the local level with the end of goal of ensuring energy decentralization. Still, much work is needed to increase awareness on this issue as plenty of respondents remain neutral with regards to all the issues raised. That can be done via various means where different actors must be involved.

2 Approach

In this section, we describe the approach we take in this report to meet the purpose and objective set out in the previous section. We describe how we define social acceptability and the way we draw conclusions about types of consumers in our project. Then, we explain how we carried out our main data gathering instrument: a survey.

2.1 Social acceptability

Social acceptability is a central notion within SUSTENANCE. As we proposed before, our socio-technical perspective on local energy systems includes acceptability as a potential "non-technical barrier to autarky" (SUSTENANCE D3.1, p.9). Generating local knowledge and insights about social acceptability of certain socio-technical energy systems, for example as implemented in SUSTENANCE, is a pre-condition for successful and long-term innovations. It has become clear that acceptance is influenced among others by being allowed to participate (ter Mors and van Leeuwen, 2023; Enserink et al., 2022; Ryder et al., 2022) and that it is a perhaps reductionist expression of much more complex underlying processes (Fournis and Fortin, 2017; Lagendijk et al., 2021; Mancini and Raggi, 2022).[1]

Answering this call to uncovering the complexity underlying social acceptability, we here analyse the results of a survey to gain insights into the ten dimensions of autarky which we developed elsewhere (SUSTENANCE D3.1-3.3). Hence, the analysis into the factors and conditions influencing social acceptability on the topic of autarky in local energy systems is organised along the types of autarky dimensions: technical-physical and socio-regulatory (Figure 1).

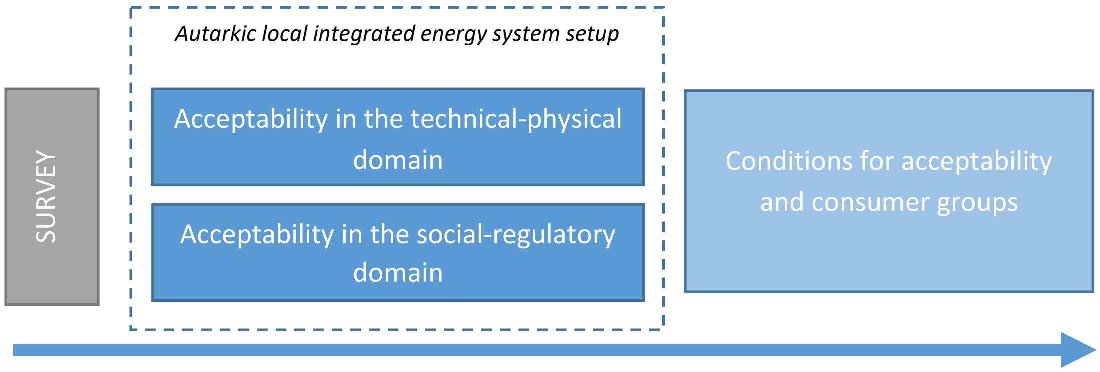


Figure 1 Overview of the research process leading to social acceptability and consumer groups.

These dimensions can be considered as leads to the conditions for social acceptability. Thus, there were questions in the survey that addressed each of the ten dimensions to a different extent. Annex A shows which survey question was linked to which dimension. As this report is exploratory, we use the results of the data to hypothesise about how each dimension needs to be organised to enable social acceptability. Furthermore, it will also give us preliminary insights into types of consumers and the way they perceive and approach energy autarky.

[1] This finding corresponds with research carried out on the notion of 'Not-in-my-backyard', which might be seen as an expression of the flipside of acceptance, namely 'resistance'. This notion has also been found to be too reductionist and overly simplifying more complex empirical situations (cf. Sovacool et al., 2022).

2.2 Methods

2.2.1 Survey

To generate data on the social acceptability of our energy autarky dimensions and gain leads to potentially existing consumer types, we have set up a survey covering various topics concerning local energy systems. The survey answers to the observation that there was a lack of information on particular user characteristics including motives, socio-economic status, and acceptance (SUSTENANCE D3.1, p.45). Thus, blocks of questions cover household background variables, technical data, energy production and consumption data, and statements meant to elicit perceptions about topics related to sustainable energy production and use (see Annex A for complete list of questions).

An important note is that at the time of writing, the survey was not yet closed for new responses. Due to unforeseen project process related issues, it was not possible to start the survey earlier and complete it before the deadline of this deliverable. However, all results presented were compiled a little under a week before the deadline of the deliverable to enable the largest possible sample. This means that all results we show here are preliminary and may change in future publications.

2.2.2 Sampling

The survey is administered using online survey software Qualtrics, for which University of Twente has a licence. The survey was developed in English and translated into the languages participating in SUSTENANCE, i.e. Danish, Polish, and Dutch to reduce sampling bias for people speaking English and increasing the sample.

The populations we address in each SUSTENANCE country are roughly speaking the regions around the municipalities within which our demonstrator sites lie. For the Netherlands, this is the municipality of Olst-Wijhe. For Denmark, this is Skanderborg municipality, and for Poland, this is Przywidz and Gdansk. However, questions at the start of the survey also allow respondents from other origins to participate, for which we can control. If those samples become large enough, they can be used as control samples.

For each of the municipalities, the optimal way of administering the survey was applied. This included local commercials newspapers, social media, newsletters of the project partners, the project website, etc. The survey was opened in May 2023 and will remain open until the timeframe becomes too long to guarantee independent samples and similar situations for each respondent. Optimally, we target 250 respondents for each country sub-sample. At the time of writing, 257 responses were logged through an anonymous link, and 60 using a QR code. There are 81 responses from Poland, 79 from Denmark, and 133 from the Netherlands. Not all responses are complete, so where possible we report the number of counts for the results we describe.

2.2.3 Data analysis

We conduct exploratory data analysis on each of the ten energy autarky dimensions. This entails mainly descriptive statistics, such as frequencies. We then link these quantitative results back to the ten dimensions to discuss how they are relevant for the notion of social acceptability. Any answering pattern might then lead to consumer types with particular outlooks on energy autarky.

3 State of the art: 10 autarky dimensions

3.1 Physical-technical dimensions

3.1.1 Technological dependency

The diffusion of technologies has been studied over the years where it was noticed that social and technical elements must exist simultaneously to unlock a technological potential. This is also the case for energy communities (Essletzbichler, 2012). This depends on the attitude of the consumer, considered either a rational economic agent that will take actions or an indifferent one. Moreover, the design of energy technologies affects whether it is deployed at the household level or not. Examples of technologies that can be installed include solar photovoltaics, smart meters, and storage batteries. Still, just because the technology is available, it does not mean that the latter will be deployed at the community and household level. In fact, some of them even were met with opposition which highlights the inability of the stakeholders in the energy sector such as governments and energy companies to fully consider the elements that impact deployment of renewable energy technologies (Chadwick, Russell-Bennett & Biddle, 2022). Other factors that play a role are the way the technologies such as smart grids are set up; the climate; the amount of heating and cooling required and the technological capacity (Obinna et al., 2017). Despite this reality, further research is needed to understand household decisions, influences based on the different types of technologies (Chadwick, Russell-Bennett & Biddle, 2022), in addition to the way digital technologies are being established locally based on business models (Hiteva & Foxon, 2021). This is important given states push especially in Europe to increase technology sovereignty by relying on local communities in this local energy ones (Edler et al., 2023) as the type of technology used for energy generation is closely related to the economic growth of a country (Fei & Rasiah, 2014).

3.1.2 Local renewable energy sources

In the context of mitigating climate change in the energy sector by reducing greenhouse gas emissions, the transition to an energy system based on Renewable Energy Sources (RES) is crucial. Furthermore, their potential of decentralised energy production makes RES a core element of more autarkic local energy system set-ups. Thus, this autarky dimension relates to the degree to which the local energy demand is covered by local RES (cf. SERENE Deliverable 3.3). Although most of the literature addresses relatively commonly available technologies such as solar photovoltaics (Khoodaruth et al., 2017; Li and Han, 2022; Mutani and Todeschi, 2021; Walters et al. 2018) and wind turbines (Firestone et al., 2012; McEwan, 2017; Vanegas Cantarero, 2020), some authors also address less prominent technologies such as anaerobic digestion (Chodkowska-Miszczuk et al., 2019), presumably owing to the more limited area of application.

While the literature on RES by themselves is burgeoning, also with a growing body of literature specifically in the social sciences and humanities domain, sources covering RES in local communities working towards autarky is rather scarce. However, where this connection is made, it tends to be strong. In some cases, in Germany, RES were even inseparably linked to autarky as reflected in the notion of “renewable energy self-sufficiency” (Hauber & Ruppert-Winkel 2012). Nevertheless, Hauber and Ruppert-Winkel (2012) also describe that the development of RES in some cases started as incremental system change without an actual vision of autarky being present as such. While this might have been more common at their time of writing, the link between RES and self-sufficiency has presumable only grown stronger. On the other hand, the case of Lithuania has also shown that on a larger level, it is not necessarily the first step towards becoming more energy-independent to invest in RES right away. Sattich et al. (2022) report that Lithuania only began to expand its RES capacity once a basic level of national energy security was achieved. Although this is not strictly an example of autarky related to local communities, it is still relevant for locales that are not as electrified, suffer from black- or brownouts, or are subject to a fragile energy geo-politics situation: in such cases, localising energy production from RES may come second after ensuring a basic level of energy provision. Besides prioritising energy security, it may even be more difficult for places with strong pre-existing ties to fossil fuel production and consumption to break away the path dependence and socio-technical lock-ins (McEwan, 2017). This may be especially difficult for smaller, remote places, such as islands, as the examples of Malta and Mauritius show (Franzitta et al., 2016; Khoodaruth et al 2017). In terms of decision making on the local level, the literature explicitly mentions two aspects that need to be considered. Given the trade-offs between the placement of RES, e.g. solar parks or wind turbines, it becomes more and more obvious that RES need to be classified as a specific land use (Poggi et al., 2020). If this happens, it should also be included in the normal policy and planning processes regarding spatial development. Finally, it cannot be denied that any tangible benefits relating to a RES project on the local scale need to be clearly communicated to ensure transparency and increase social acceptance (Busch and McCormick, 2014).

3.1.3 Settlement characteristics

In principle, the assumption is that autarky is achievable regardless of the characteristics of the settlement in question. In the end, any configuration of size, urbanity/rurality, building types, land uses, building density, connections to outside systems (e.g. of waste management, water treatment, mobility), and social cohesion is assumed to be able to realise an autarkical local energy system. In broad strokes, our understanding aligns with Petersen's (2016, p.1) definition of 'community', which entails:

> *"a specific geographic area, composed by similar physical characteristics and a set of social networks. A community has no fixed size and can range from a batch of physically similar buildings up to almost a district size area containing multiple uses, but connected by a shared identity."*

The literature dealing with this aspect of autarky is located mostly in the Global North (e.g. Firestone et al., 2012; Kim et al., 2015; Kim, 2017; Komendantova et al., 2018; Winter and Le, 2020; Poggi et al., 2020), a smaller share located in the Global South (e.g. Walters et al., 2018), especially South Africa (due to its influential Renewable Energy Independent Power Procurement Programme; e.g. McEwan, 2017; Davies et al., 2018), and small island developing states (e.g. Khoodaruth et al., 2017; Niles and Lloyd, 2013). The need for research to focus more on the Global South has also been explicitly voiced (Vanegas Cantarero, 2020).

A first aspect in this dimension is the appropriateness of certain types of RES for a particular geographic situation. Due to geographical variations throughout an area, one sort of RES may be more suitable for one community than for another (McEwan, 2017). For example, the anaerobic digestion cases studied by Chodkowska-Miszczuk et al. (2019) were explicitly tied to rural areas where sources of feedstock for the plants are close-by. Placing such a plant in an urban area would complicate the supply chain and defeat the purpose of local energy production. Furthermore, the pre-existing land uses for areas under consideration for RES in a community may conflict with the envisioned new or combined land use and opposition may arise (Hauber and Ruppert-Winkel, 2012; Poggi et al., 2020).

There are also several socio-political aspects that need to be considered. The distribution of more and less affluent areas is a characteristic that may produce obstacles in taking eco-friendly measures that pave the way towards an autarkic energy community (Winter and Le, 2020). Another line of conflict may be present claims to land use, ownership or access voiced by local actors. This may become especially problematic, if these conflicts are depoliticised or ignored (McEwan, 2017). It is also possible that the social cohesion required to create a commnity strong enough to achieve autarky is less present in urban areas vis-à-vis rural ones due to the in many places looser social fabric (Kim, 2017).

3.1.4 Building characteristics

A large share of a community's energy footprint comes from the energy performance of the buildings located in it. This autarky dimension relates to how well the buildings within a local community are retrofitted making them more "self-sufficient and carbon-neutral in their supply for residents' demand of heath and cooling" (SUSTENANCE Deliverable 3.3, p.20). Thus, much of the literature concerning building energy performance applies here but will not be covered. We focus on a few sources that explicitly talk about autarky aspects. In a study of the building stock in Denmark, Petrovic and Karlsson (2014) found that a move to RES for supplying energy might in some cases be insufficient to achieve autarky, if retrofitting potentials, such as improving building insulation, are nare not leveraged. To support the creation of circular cities, i.e. cities with as much as possible closed production and consumption loops, Paiho et al. (2021) found that photovoltai panels would be the best option for prioritising "local production and energy self-sufficiency" in their urban case in Finland. Fortunately, Li and Han (2022) also mention in their modelling study that the negative effect of shadow cover on solar energy generation in urban environments is limited, the better the mix of taller and shorter buildings. Finally, there is a spill-over effect of what Mutani and Todeschi (2021) call "green technologies", in which they not only include solar photovoltaics and solar thermal technologies, but also green roofs to mitigate the urban heat island effect. While these technologies not only reduce the energy dependence of buildings, but they can also increase the liveability and attractiveness of a community.

3.1.5 Complexity of energy uses

Energy issues in a community do not only concern energy production from RES or the final consumption of electricity. Energy use in a community is complicated by other overlapping dimensions. This may relate to (a) synergies with other sectors, (b) flexibility and demand governance schemes, or (c) system-level planning and coordination (cf. SUSTENANCE Deliverable 3.3). The literature on autarky in local energy systems covers various aspects depicting the complexity of energy use, including political, cultural, and cross-cutting aspects.

As desirable as 'autarky' or synonyms may sound for some, it presents challenges for places and communities that are embedded in pre-existing networks of all kinds. For example, the energy policy and infrastructures of local communities also depend on national energy policy and budgets (e.g. in South Korea: Kim, 2017; Lee and Kim 2016) or on foreign aid (Niles and Lloyd, 2013) or other international actors (McEwan, 2017). This is a common situation far more pervasive than the empirical cases presented by the aforementioned sources. How to disentangle the local communities from higher-level policy structures and on what aspects to do so is a question that needs to be addressed in each case individually and within the local socio-legal possibilities. Walters et al. (2018) also emphasise the relevance of understanding pertinent laws and incentive schemes for local desires of energy autarky. Issues of legitimacy can also result from putting too many responsibilities on private actors (McEwan,

2017) or the well-known resistance to RES projects (Hauber & Ruppert-Winkel 2012; cf. Batel and Devine-Wright, 2020).

The use of energy has played a cultural role for long. White (1943) has even posited that "culture develops as […] the amount of energy harnessed and put to work per capita per unit of time increases". While several societal developments have made this definition highly questionable and new perspectives have arisen, there is something to say for the necessity of nurturing a 'renewable energy culture' (after Stephenson et al., 2010; in Walters et al., 2018). However, as a South Korean case illustrates, the potential to cultivate energy community cohesion is negatively influenced by long working hours, which reduces the time budget remaining for individuals to invest (Kim, 2017). Sometimes, the urgency of mitigating climate change is not a driver to engage in the energy transition at all, as the implementation of RES is also sometimes viewed from a vantage point of 'technological progress' with its techno-optimistic connotations (Busch and McCormick, 2014).

Cross-cutting aspects are those, where the literature explicitly relates issues relating to the local energy system to other sectors or domains that were not previously mentioned. For example, in the decision-making about energy-related measures, communities may decide to engage in energy-saving behaviour, because money must be saved, not because it is perceived as a prudent thing to do (Winter and Le, 2020). This assigns climate change a more secondary importance in decision-making processes (Busch and McCormick 2014). Busch and McCormick (2014) also state that decisions to engage in the energy transition have been based on local-level economic utility, composed of job, income or tax revenue effects of proposed measures. Conflicts and trade-offs between land uses are also a recurring theme. A study on the Hawaiian island of Kauai found that it would not be possible to achieve both food and energy independence at the same time due to the rivalry of required land (Kim et al., 2015). In the Polish and Czech cases studied by Chodkowska-Miszczuk et al. (2019), there was a trade-off between growing energy crops for powering anaerobic digestion plants versus other agricultural crops. As these examples show, and is emphasised by Paiho et al. (2021), energy autarky is also an important element in making economies (more) circular. In sum, the complexity of energy use and the various dimensions that influence the energy sector mean that local communities are advised to engage in an integral, decentralised decision-making approach for a successful energy transition on the local level (Poggi et al., 2020).

3.2 Socio-regulatory dimensions

3.2.1 Scope of autarky

Sectors increasing the complexity for energy autarky do not only have to be taken into account in local decision making. They must be actively considered in terms of pushing autarky in those domains, too. This requires an encompassing vision of local cross-sectoral autarky, which, in turn, can increase support of RES projects (Firestone et al., 2012) and have a positive effect on community members' sense of belongingness (Koirala et al., 2018). Even if, the meaning of local energy autarky is not agreed upon with everyone, or negotiations are still ongoing, visions can serve as a boundary object that motivates different stakeholder groups attaching different meanings to it in different ways (cf. Hauber and Ruppert-Winkel, 2012).

3.2.2 Alignment of energy values

Citizens in their private households or within the broader community adopt specific energy values considering various elements. These include mainly social ones to ensure energy independence and participation, deriving specific local benefits as well as being environmentally responsible. Economically, one can mention the actual consumption of energy and its cost. All of these require a high degree of awareness reflected in the willingness of participation in the decision-making process and taking the necessary steps; the level of knowledge and engagement in technology and new forms of energy in addition to whether transparency and trust exist (Adams et al., 2021). In fact, even with consumers awareness of the need for energy transition, a great discrepancy remains when it comes to taking practical actions. Among others, they prefer to either maintain the status quo; make minimum efforts; exaggerate the loss and risks associated with their behavioral changes; continue having the same attitude due to time, efforts and money investments; compare their behavior with others considering the social norms and seek rewards and incentives before changing (Frederiks et al., 2015). In nations such as Switzerland and Germany, citizens consider their governments and energy supplies as the ones responsible for securing a proper energy transition. This is despite their support for the local scale establishment of distributed energy systems further enhancing the provision of renewable energy. Factors leading to such support include the belief in the negative impact of climate change; the need to ensure national energy independence as well as local autarky (Seidl et al., 2019). Besides, citizens' concerns from different aspects such as safety and social ones heavily affect energy transition (Correlje et al., 2022). Given this situation, some are focusing on the creation of the "Energy Citizen" using criteria and factors (Goulden et al., 2014), connecting personal choice with market mechanisms (Schwartz, 2018), simply understanding the human dimensions in this context (Steg et al., 2015), where public acceptability is very relevant (Demski et al., 2015). Others claim that the economy mainly seeing renewables as an investment in the long-term affect consumers perception and -behavior (Grebosz-Krawczyk et al., 2021). Hence, the use of energy values as a metric is a very challenging one considering all OF the above. Nonetheless, it remains an important means in the analysis of energy transition especially when comparing different communities having consumers with diverging values. Further research, surveys and behavior analysis is needed to understand how to effectively ensure that change in practice and not only in the value system of a community occurs considering value change in institutional settings (Milchram et al., 2019).

3.2.3 Formal self-governance

Self-governance as a form of self-sufficiency is not a new concept but has been seen historically as well as more recently with the outbreak of Covid19 as a necessary means for nations to guarantee their political independence at different levels including community and individual one (Helleiner, 2021). In the context of energy, the end goal is having flexible, sustainable, and resilient energy supply framework (Koirala et al., 2019). In this context, the concept of energy citizens has emerged given the many roles they can play even when considering new and innovative business models (Mihailova et al., 2022). This also represents a way to support low-income households looking to achieve energy security by considering local priorities (Biswas et al., 2022). The increasing involvement of communities is not always easy as there are significant barriers facing energy decentralization. Some even consider this approach as inefficient, given its incapacity to consider existing inequalities in society (Catney et al., 2014). Therefore, numerous concepts have emerged as to how this may occur considering the differing capabilities of developed and developing countries (Koirala et al, 2016), and whether a top down or bottom-up approach would best tackle this dilemma (Hoffman & High-Pippert, 2010). In any case, ambitious plans are being put up by cities and towns to achieve 100 percent sustainable energy locally (van der Schoor & Scholtens, 2015). Each community has different motivations for realizing this goal (Juntunen & Martiskainen, 2021), where leaders, existing networks and the overall general social context are very relevant (Ruppert-Winkel, 2018). This form of self-governance has been proved in specific experiments in places such as the Netherlands (Homan et al., 2019), while other places are experimenting with renewable energy and the ability to reach self-sufficiency (Jurasz et al., 2020). In these situations, citizens are considered self-consumers where emerging technologies are being deployed such as blockchain (Di Silvestre et al., 2021). This has been coined as a form of energy independence without control however left to the various authorities (Ecker et al., 2018). This is as these communities are leading a change in the socio-technical regimes (Gui & MacGill, 2018). Regardless of the approach taken, policymakers have a great role to play in influencing communities and households (Engelken et al., 2018). Still, a balance needs to always exist to avoid having conflicts between local interests and national ambitions as well as to consider many other factors related to the functioning of the state itself. This as various actors have a say including investors, local officials, and policy entrepreneurs (Young & Brans, 2017), while community approach represents an alternative energy future (Hoffman et al., 2005).

3.2.4 Energy and land regulations

Energy laws globally focus on centralized energy systems (Koirala & Hakvoort, 2017). Awareness of rules related to energy is not always the case for citizens and communities (Malajowicz et al., 2023), especially as their design is a very complicated matter (Iychettira, Hakvoort & Linares, 2017). However, given the increasing decentralization of electricity provision as well as the involvement of communities and citizens, some are arguing for a new bottom-up approach to laws and policies. This is in the context of novel electricity market frameworks based on households and communities' generation, consumption and trade in renewables. Regulatory systems need to be established supporting the decentralization of energy markets and the proactive participation and organization of the energy sector. So far, the literature on this from a legal point of view remains insufficient. Still, it is clear that local governments have an important role to play in facilitating the further development of energy communities legally (D'Alpaos & Andreolli, 2020). Already in places like Greece, a new law on energy communities have been adopted (Douvitsa, 2019), while others such as Austria, Italy and Spain have implemented European directives nationally in relation to energy communities (Biresselioglu et al., 2021). These directives have been considered as a driver for national and local actions (Krug et al., 2022). Communities elsewhere are benefiting from rules mandating for instance that a specific amount of electricity must be produced from renewables (Outka, 2010). Examples of rules supporting energy communities are the Dutch postcode law for the exchange of local energy; New York Community net-metering; governmental grants in Scotland and the United Kingdom in addition to the German provision of grid priority access (Koirala & Hakvoort, 2017). In places where municipalities adopted strategic energy plans including laws to support communities, numerous challenges were noticed including the lack of technical expertise of such administrations, the diverging priorities with local communities and deficit in the procedures adopted (Petersen, 2018). This is as stakeholders besides the communities and households influence their role via legislations such as planning permits and energy subsidies (Fouladvand et al., 2022). This is why suggestions for regulatory interventions have been made to further enhance prosumer market alignment. Examples of instruments examined include real-time retail electricity prices, and an increase of fixed network charges (Klein, Ziade & de Vries, 2019). Meanwhile, factors such as networks; coordination across authorities and standardization may create obstacles to having energy communities (Busch et al., 2021). Finally, and based on experimentation and analysis conducted in the Netherlands, it seems that an appropriate legal framework requires a reform that extends beyond simply energy law itself (Swens & Diestelmeir, 2022), where a debate concerning this particular matter is taking place in the literature in the broad sense (Sokolowski, 2020).

3.2.5 Social Organization

Social organization as a concept applicable to communities is not new (Mancini, Bowen & Martin, 2005). Actors from local communities are taking the role of either an investor or a contributor to for instance renewable energies projects and electricity cooperatives. Citizen's involvement and participation is of outmost importance. Still, for the time being, the number of local members engaging in such activities remains low. This is as the social connection to a community; trust and social norms affect the decision to be involved (Kalkbrenner & Roosen, 2016). In fact, citizens decide to engage locally for various motives including financial and energy autonomy ones where the educational level plays an important role (Knox et al., 2022). Meanwhile, having a shared vision, concrete goals and continuous communication facilitate the choice of taking part in an energy community (Van der Schoor & Scholtens, 2015). This is as different visions and framing exist influencing the energy system locally where overlaps between them also takes place (Morrissey et al., 2020). This in addition to several factors related to families and their components (Balest et al., 2019). Moreover, they actively choose the type of renewable energy to install (Van der Schoor et al., 2016). Nonetheless, in many cases and despite their willingness to put efforts, the consumer is looking to play a passive role which requires a new type of social organization with minimum effort from users (Bogel et al., 2021). This in contrast to studies highlighting that direct engagement was a key to the success of energy communities (Schumacher et al., 2019) where local institutional environments must be considered (Wirth, 2014). Citizens in this context must be capable of adapting to changes to energy systems considering the wider community (Koirala, van Oost & van der Windt, 2018) with the end goal of establishing collaborative ones (Boulanger et al., 2021). Given the importance of energy communities socially, studies attempt to examine them through the lens of energy justice, energy democracy and community empowerment (Bielig et al., 2022). In this context, it is important to highlight that social organization excludes individuals who do not belong to a group despite their focus on making a shift in renewables (Klein & Coffey, 2016). Moreover, for the time being, citizen science has not yet been directly associated with energy communities (Wuebben, Romero-Luis & Gertrudix, 2020).

3.3 Outlook on consumers in India

3.3.1 Context

In SUSTENANCE, consumer opinions about local integrated energy systems in Denmark, Netherlands and Poland are indicated based among others on the results presented below, but such assessment of consumers in India is uncertain. Thus, the following literature review provides a basic understanding of Indian consumer opinions.[2]

World Bank data for 2020 suggest a substantial difference between the Indian and European Union consumer energy markets. Firstly, average income per person in the EU, measured in constant US$ price

[2] Inter alia, SUSTENANCE partner IIT Bombay performs social studies on distributed energy systems.

parity, is about eight times higher than in India, while income disparity across EU countries is lower than in India (Gini coefficient are 30.1 and 35.7, respectively). Meanwhile, the EU average energy consumption per person is fivefold of the Indian one. Secondly, the rural population in the EU is 25.4% of 450 million citizens while 61.1% of 1480 million citizens in India, which implies that Indian energy consumption is driven by the low-income, rural population contrary to the EU's middleclass urban population. Thirdly, in the EU grid access is about 100% for several decades and availability of power is nearly 24 hours a day. In India, access increased from 76% in 2010 to 96% in 2020, which means that many millions still lack access to power and those who do have access obtain power on average during 20 hours with black-outs while power supplies in many regions are unreliable. Moreover, the growing demands for air conditioning cause larger hourly variation in the power demands; for example, the power consumption per capita in large cities varies by factor 2-2.5 along with large differences in tariffs (Sasidharan, 2021).

From an EU consumer perspective, local integrated energy systems can be motivated as an action for good environmental qualities, or a cost-effective approach to the variable prices while in India as a basic need. Hence, distributed energy systems cover a large share of power supply in rural areas, using kerosine and diesel generators, as well as renewable energy. Photovoltaics are the main renewable energy resource. While access to power increased by 8% between 2016 and 2019, the photovoltaic (PV) capacity grew by 47% to 4.5 GW, of it 27% off-grid, based on the data of International Energy Agency.

Keeping that in mind, the grey literature search combined 'India', 'energy', 'consumers', 'off-grid', 'distribute', 'local', 'citizens', 'initiatives', 'willingness' and similar terms for the acquisition of the empirical papers on consumer opinions about distributed energy system several studies have been found. Nearly all of them address the rural poor, rarely the urban and rural rich, but none is found about the urban poor; e.g., distributed energy systems in slums. That bias in the literature search could be caused by biased applications of distributed energy systems, or by the scholarly bias driven by a focus on social development rather than commercial interests. Below, only key findings are summarized.

3.3.2 Consumer opinions

Consumer opinions about distributed energy systems (EMS) refer mainly to low-income people in rural areas that miss access to the grid power availability. Studies show that those consumers are rather moderately interested in such systems while they prefer access to reliable power services. A survey in 1500 rural communities without access to grid in Uttar Pradesh has shown low interests despite an acknowledgment of the distributed energy systems that are rarely considered trustworthy. Similar observations were made in a study on co-financing of PV, because high costs and poor performance of installations are expected. Given that the costs of installations are considered as the major obstacle for adoption of PV, subsidies are found helpful but even the subsidized systems confront negative perceptions as unreliable and burdensome; the PV is often perceived as a 'fake' energy resource (Akter and Bangchi, 2021). A study on 9000 residents in rural areas with high share of low cast and tribal population of low income has also shown only 1% annual increase of the PV adoption. Limited acces to grid and frequent power interruptions are main incentives for the PV adoption but costs and poor information cause major barriers even in the subsidized projects. The scholars concluded that higher social trust is necessary to overcome the consumer preferences for grid, in particular the rural consumption is subsidized, thereby provides cheap power (Blankenship et al., 2019).

3.3.3 Willingness to pay

In rural areas, high price elasticity is observed, which means that minor price increase cause large decrease in consumption. In the rural areas of Bihar that is the poorest state in India that high price elasticity is caused by competitive retail market of energy resources, given consumers choices of using grid, diesel generators, kerosine and PV systems. Large differences in willingness to pay for PV systems are observed when households without PV (non-users) and the PV users are compared. In the absence of grid, the annual willingness to pay of the non-users is about US$ 2 whilst US$ 6 of the users. If grid is accessible, the willingness to pay of the non-users drops US$ 0.20 whilst that of the users remains as high as US$ 2 a year. Therefore, the scholars conclude that trustful information is essential, which is delivered mainly through relatives, friends and local institutions; for example, in schools (Burgess et al., 2017).

High willingness to pay for the distributed energy systems is also observed for the energy services in addition to grid because of low reliability on grid. A survey in 714 village with 8500 household shows that one additional hour of power could attract an additional US$ 0.87, one hour in the night even US$ 2.48, additional ten percent power services US$ 3.89, whereas unconnected households are willing to pay US$ 6.18 for a grid connection. Comparison to urban areas with and without access to grid confirms high willingness to pay for additional services. Moreover, based on statistical studies it is revealed that the rural households with access to grid live closer to urban areas and have higher income, education and cast position, and villages with high access to grid also get better services measure by hours of power deliveries by day and nights. It suggests a polarisation of the consumers in rural and urban areas with access to grid from ones without that access (Kennedy et al, 2019). High valuation of the reliable energy services is also observed in a survey among 216 households in 22 villages in 4 districts in a state where 7.2 hours of power a day with use of the distributed energy systems is preferred above 9.4 hours with grid. It implies that the distributed energy systems are attractive when they provide reliable services (Graber et al., 2018).

Those results are uncertain with regard to differences between the stated willingness to pay and taken actions. In addition to charges for energy services, a monthly US$ 4 (Rs 311) per household of residential consumers for reliable PV based power services but that positive attitude toward PV is not confirmed by uses. Among households, a wide attitude-action gap is observed. Also, large power consumers state that they are willing to pay US$ 600-700 (Rs 50,000 – 60,000) per kW based on PV or wind but they also consider regulatory, technical, contractual and financial issues. All respondents in the study express preference for the distributed energy system based on ownership of PV due to proximity of generation and consumption of power (Sen, 2020). A similarly high willingness to pay but also a large attitude - action gap is observed among 476 residential households in Pune and Mumbai. It is also found that a higher age exerts a negative influence on the willingness to pay whereas more education and higher income have a positive influence on that; however, the gap remains (Sen, 2023). These findings suggest high uncertainties in the adoption of distributed energy systems in the low-income rural areas as well as in the middleclass urban areas.

3.3.4 Demonstrators

The attitude – action gap is confirmed in demonstration projects. A PV-based microgrid with capacity building for 255 low-income, rural households in 4 communities Bihar is developed by Greenpeace and local NGO's but participation declined in 2 years after the start of this demonstrator in 2014. The unconnected households protested against that microgrid in favour of full access to grid and when grid is made accessible, the participation in that microgrid has depleted by half. Moreover, lack of metering caused overuse of power, followed by power supply during only a few hours a day. Though interests in PV were high, farmers did not replace the diesel pumps, while large farmers abandoned the rooftop PV in the hybrid solar-grid systems. Women have also protested against abandoning of kerosine for lamps and the project is not fully adopted by the communities (Sharma, 2020).

Two major conditions for successful adoption are shown in subsidised demonstrators, executed by IIT Bombay, with repeated measures in 1159 rural households in 32 energy-poor villages in three states, e.g., the subsidy per PV lamp was US$ 1.72 of US$ 8.61 retail price. One condition is that the household awareness of solar products and motivation to adopt them increases over time. This is especially important for solar home systems and solar water pumps as the repetitive propositions has increased their adoption by 60% to 70% compared to incidental proposition. Second, providing information through family, neighbours, friends and school generate participation but other means are less effective. Women are less adoptive, whereas higher education and casts are more adoptive. Higher uses of kerosine lamps increases willingness to pay for the PV. Hence, awareness and trust are key factors for the adoption (Sharma et al, 2021).

3.3.5 Business models

No studies are found on costs and benefits of consumers and communities, whereas several studies address business models. Three business models for distributed energy system are mainly used. Most popular is Capex model with purchased of PV by consumer. The Opex models are payments periodical fees to a developer, possibly with transfer of ownership or lease variants after a period of time. The rooftop rental model is also used; it is when the energy distributors rent out equipment along with fees for deliveries (Poudineh et al, 2021). The Asian Development Bank also supported prepaid cards for energy but results of the 'pay and go' models are not encouraging (ADB, 2023). It is also argued based on the expert opinions that business models for the distributed energy systems are undermined by regulations with subsidies for the retail tariff on grid (Comello et al 2016). McKinsey, however, suggests that India, Kenya, Philippines, and Cambodja have suitable conditions for such systems given supportive regulations, businesses, logistics, willingness to pay and ease of payment (Kendall and Pais, 2018).

3.3.6 Market segments

Scanning literature on the uses of distributed energy systems in India indicates two dimensions in the Indian markets: urban – rural and rich – poor. The urban - rural dimension refers to percentage people living in the rural areas with low access to grid and availability of power during only a few hours a day, whilst the urban population has high access to grid and high availability but deficient services because of frequent black-outs. The rich – poor dimension addresses income and education levels of the growing middleclass, which is usually in cities, but 15% to 20% of people at subsistence level, hardly any education, and low societal status in cities and rural areas. They cannot afford the market prices of electricity but can obtain subsidised power from grid, or the subsidised distributed energy systems. The rural poor may obtain the distributed energy systems but prefers grid, whilst the middleclass in cities may demand the distributed energy systems in order to avoid deficiencies in power services and can pay high prices; for example, inhabitants on the IIT Bombay campus and the professionals in laboratories. The rural, poor can be interested in the subsidised systems but discard it system when they gain access to grid with subsidised tariffs.

4 Results

The following section will provide the results of the survey made in three countries: Poland, the Netherlands, and Denmark. Citizens had the opportunity to respond to several questions based on which the authors of this report are attempting to understand whether the population is embracing energy autarky.

4.1 Physical-technical dimensions

4.1.1 Technological dependency

Majority of the respondents use green or renewable energy. This fact however cannot be used as a generalization given the small sample surveyed. What can be said is that more and more European citizens are shifting towards green and renewable electricity which is a good sign. Yet, further efforts are needed. The electricity supplier offers different tariffs for electricity depending on the time of the day such as during the night in all the states surveyed. This encourages consumers to be energy efficient and use the time of the day extremely wisely. This is considered a good policy installed by nations as evidenced from its use in the various nations surveyed which shows its success. Majority of households use a smart meter to record electricity use (Figure 2). This is especially the case in the Netherlands. What is interesting is that some do not even know if they have a smart meter in their houses. This happened across all the nations. Meanwhile, a good percentage of people still do not use a smart meter. In fact, more respondents report not to use a smart meter in Denmark which implies that further work is needed in this regard. This is especially surprising given the fact that as of 2020 100% of the households should have a smart meter installed.

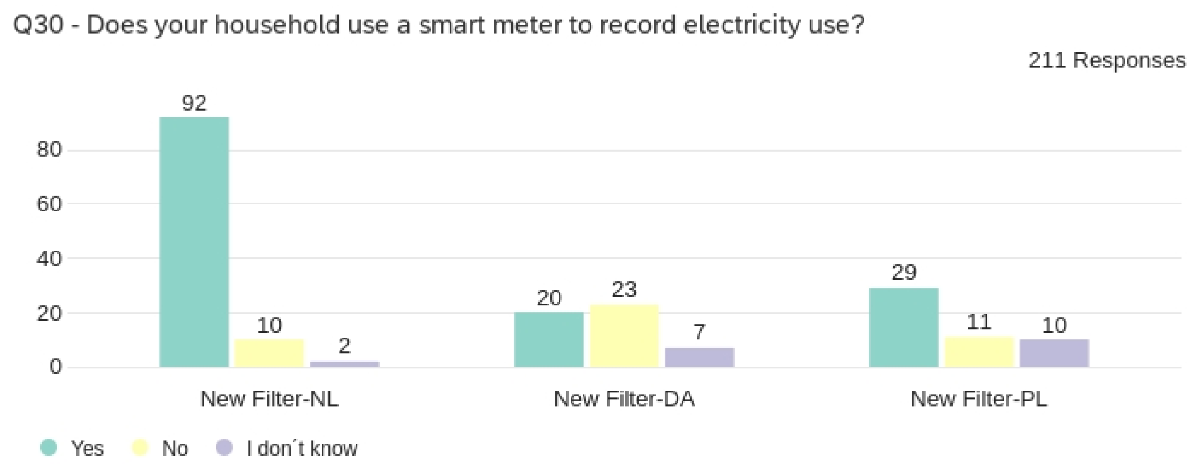


Figure 2 Smart meter use.

Majority of people do not own an electric vehicle. One can only assume that it is mainly due to financial reasons as such cars remain expensive. Among those who own one, some charge the vehicle at home while others do so elsewhere. It is worth mentioning here that due to tax exemptions on electric vehicles in Denmark, they have a significant share of the market (Arent, 2023). One may argue that not all homes have proper installations to charge such cars or that work places have also set proper ones to that end. Citizens generally in the three countries have installed solar panels for producing electricity (Figure 3). Some also have not done so but would love to do it. Moreover, many did not also install such panels. It is highly likely that the energy crisis led many households to install solar panels to reduce energy costs and for long-term sustainability. That in combination with favourable governmental policies.

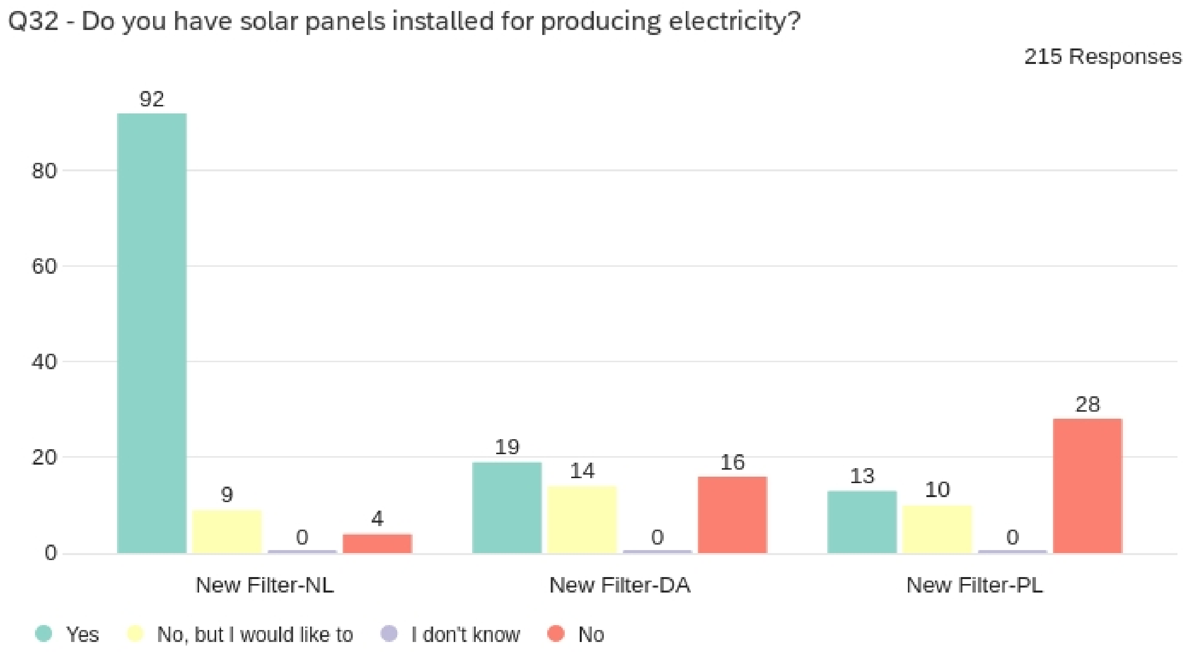


Figure 3 Having solar panels installed.

Finally, Citizens are prepared to slightly adjust their behaviour to make some efficient use of sustainably produced electricity such as not using the washing machine during peak hours (Figure 4). This highlights citizens awareness of the impact of their attitude on ensuring energy efficiency.

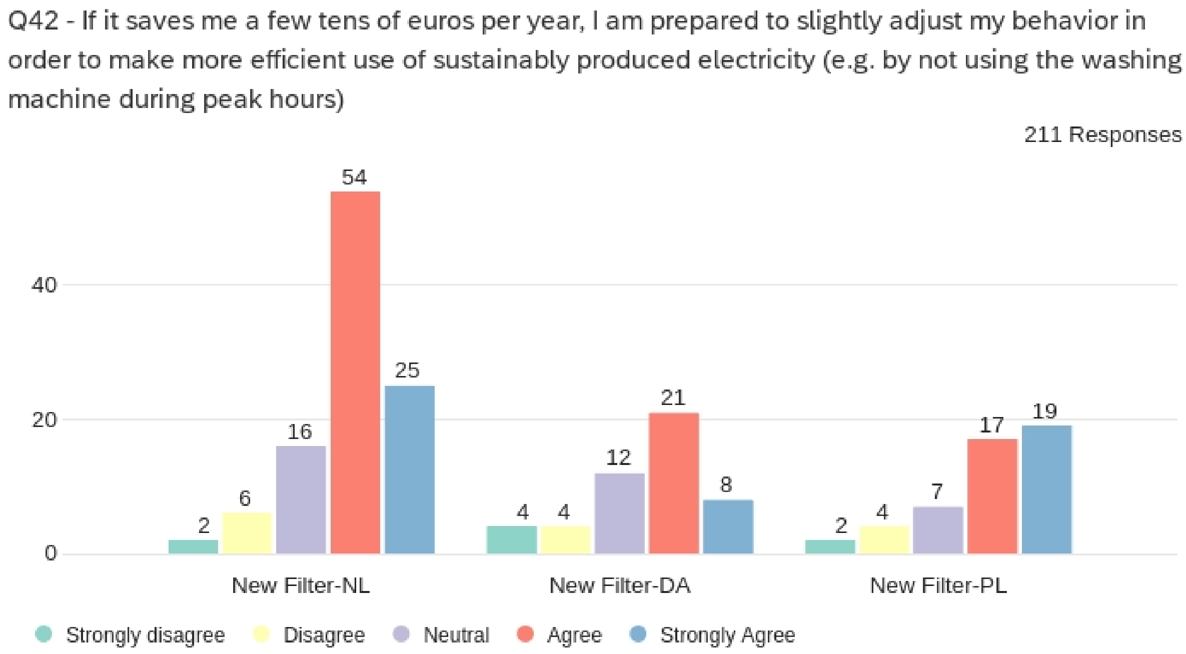


Figure 4 Citizens willingness to adjust behaviour.

4.1.2 Local renewable energy sources

Autarky in terms of local RES largely refers to the idea of self-sufficiency in terms of energy supply, ranging from installing one's own solar panels to sharing energy generation technologies in a broader community. The degree to which individuals or communities seek to become self-sufficient in their local renewable energy production as envisioned in SUSTENANCE can be measured based on four questions.

First, we asked Dutch, Danish and Polish respondents if they already use green or renewable electricity (Figure 5). The Dutch respondents (n=119) showed the largest share of citizens that already use green or renewable electricity (88%), followed by 55% of the Danish respondents (n=66). For the Polish respondents (n=57) green or renewable electricity is used by a minority of 33%.

Second, we asked if the respondents perhaps already produce their own electricity. We found that a large share of 87% of the Dutch respondents (n=120) already produce their own electricity. For Danish (39%) and Polish (27%) respondents this is a minority (n=66 and n=45, resp.). This indicates that Dutch respondents are already more self-sufficient in terms of energy production compared to Danish and Polish respondents (Figure 6).

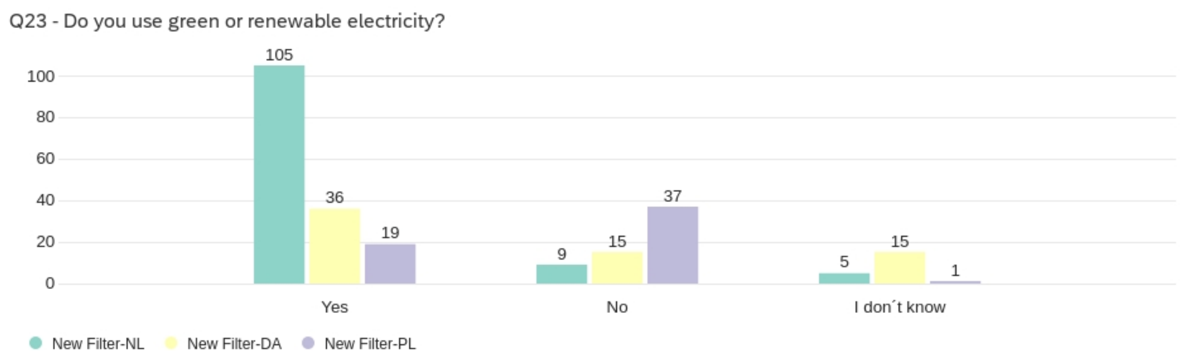


Figure 5 Green or renewable electricity use.

Third, we asked more specifically if respondents already have solar panels installed in their homes (top Figure 7) and if not, why this is the case (bottom Figure 7). We found that a large share of 87% of the Dutch respondents (n=102) has solar panels installed. 8% of the Dutch respondents does not have solar panels but would like to. It remains unclear what the main reason is for not installing solar panels for most of the Dutch respondents, as they indicated "other". For the Danish respondents (n=49), there is similarly a majority of 39% that already owns solar panels. 29% of the Danish respondents do not have solar panels yet but would like to have them. Among Danish respondents that do not have solar panels, the majority indicates that it is because it is too expensive to install solar panels. For the Polish share of respondents (n=51), the pattern is a bit different: a majority of 55% answered no to this question, 25% does have solar panels installed and 19% would like to. Of those respondents that do not have solar panels, most indicate that it is too expensive or not possible because they are renting their home. This shows that solar energy production specifically occurs more among Dutch and Danish respondents compared to Polish respondents, as Polish respondents are mostly not able to install solar panels as they live in rented homes.

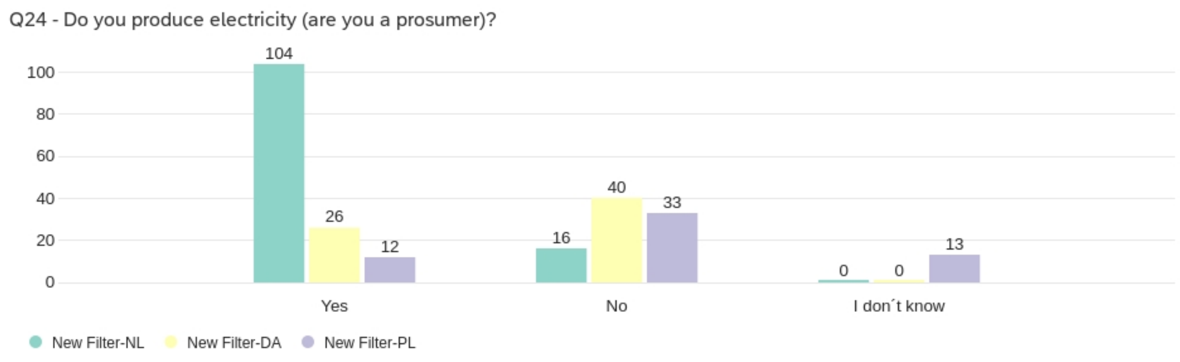


Figure 6 Electricity prosumers.

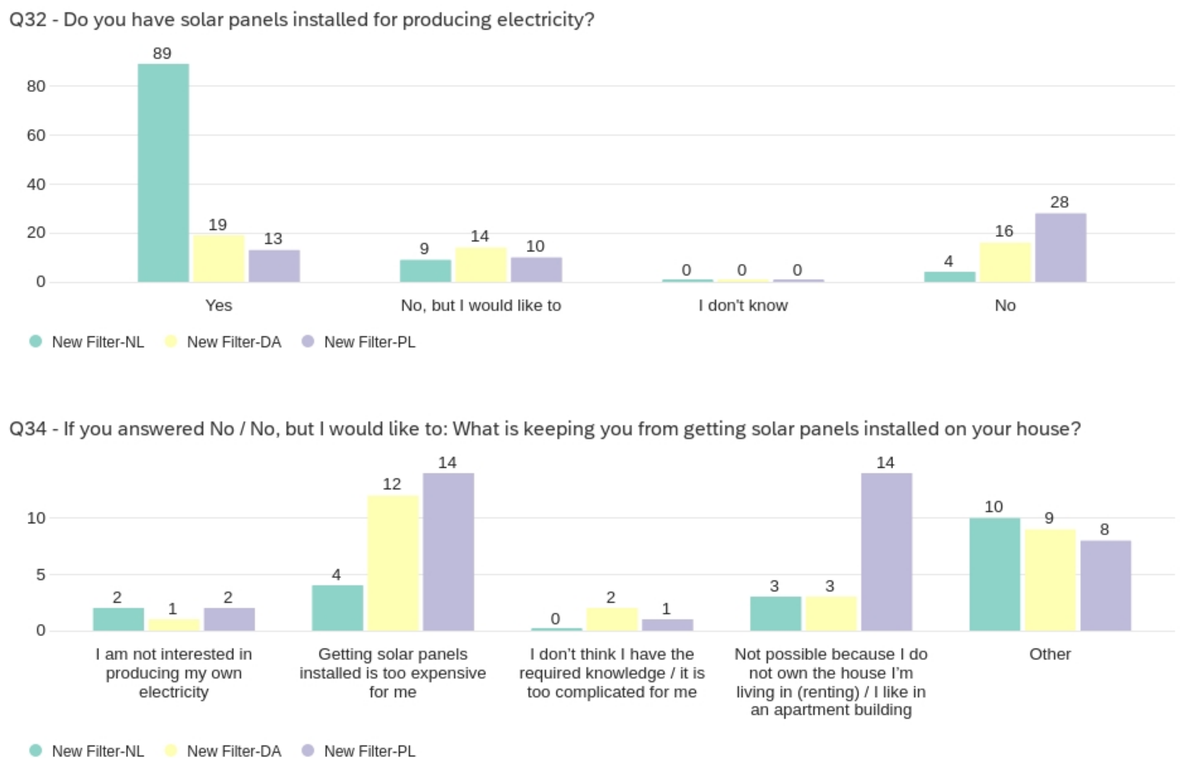


Figure 7 Electricity-producing solar panels (top) and barriers to install solar panels (bottom).

Fourth, we asked respondents whether generating one's own energy locally is an important value in their social network (Figure 8). The previous questions focused on their factual, current status on producing energy but while respondents may not be in a position to do so currently, they might have a desire to produce energy in the future. Indeed, we find that while Polish respondents (n=43) mostly do not produce their own energy with solar panels or else, the majority of 66% does recognize this as an important value in their social network. Among Dutch respondents (n=95) similarly a majority of 45% agrees with this statement, while among Danish respondents (n-44) the majority of 55% is neutral in this regard.

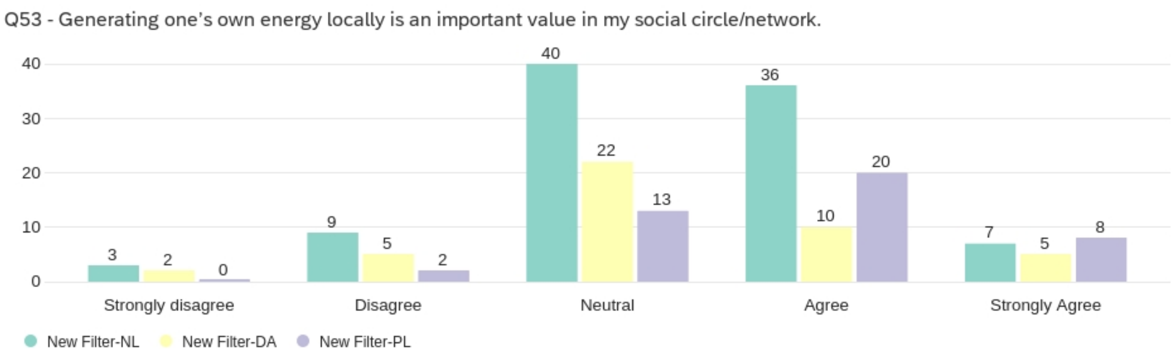


Figure 8 Importance of local energy production in social network.

In sum, we find that most Dutch respondents and quite a share of Danish respondents are already in a position to produce their own renewable energy, for instance with solar panels, and are therefore already self-sufficient to some extent. The Polish respondents appear to be interested in generating their own green energy as it is a value widely shared in their social network but are often not in a position to do so. For example, because solar panels are too expensive or can simply not be installed as they are renting and not owning their homes.

4.1.3 Settlement characteristics

Keeping in mind the divergent size of the different sub-samples, the results indicate differences in the ***composition of the settlements*** when it comes to the types of houses (Figure 9). Dutch respondents indicated to inhabit a mixture of 3 or more houses attached together, 2 houses attached together and

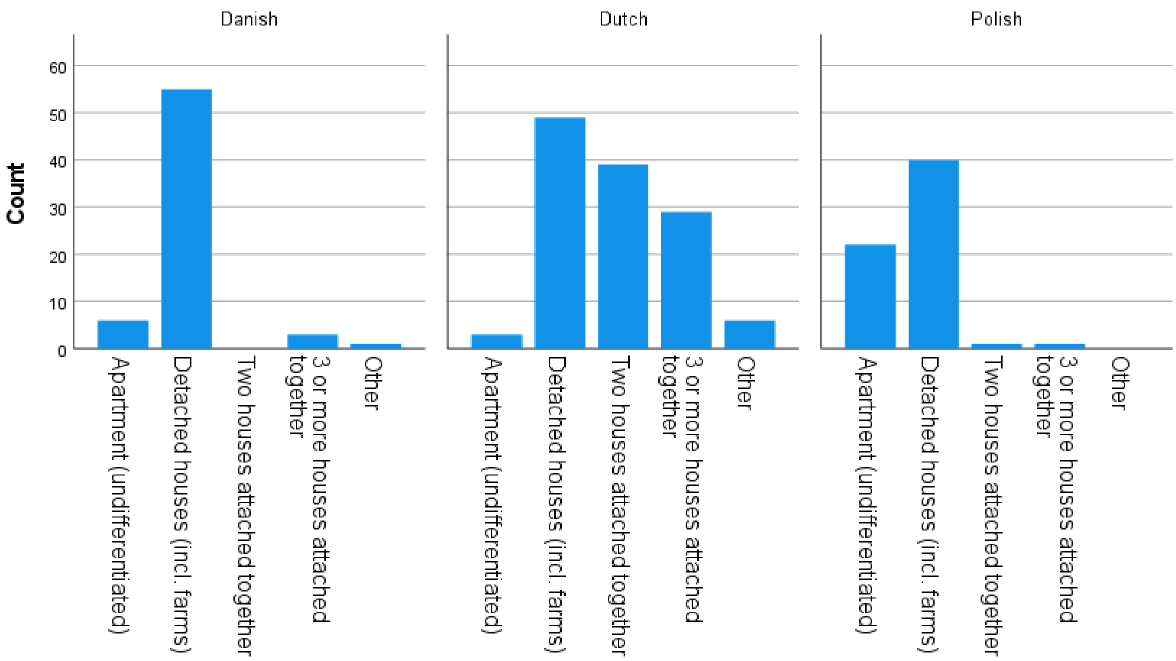


Figure 9 House types per respondent sub-sample.

detached houses. However, for both the Danish and Polish sub-samples, a clear peak is visible in the category of detached houses. We also observe that there are relatively more apartments in the Polish sub-sample, than in the others. In all three sub-samples, respondents indicate that their neighbourhood is characterised by abundant green and water elements (approx. 77% for Netherlands and Poland; approx. 90% for Denmark). The share of respondents stating their neighbourhood is moderately green and blue is highest in the Netherlands with about a quarter stating so.

At the time of writing, approximately 91% of the respondents in the Netherlands ***owned their house*** (n=109), versus 90% in Denmark (n=59) and 95% in Poland (n=54). While the distributions of how many ***people respondents share their homes with*** is quite balanced in both the Danish and Polish sub-sample, the Dutch sub-sample shows a clear over-representation of 2-person households: 69 versus 19 4-person households that were the second-largest category (Figure 10). In the Danish sub-sample, 2-person households are also counted the most, but with a much smaller difference between the largest and second-largest category. In the Polish sub-sample, 4-person households were the largest category.

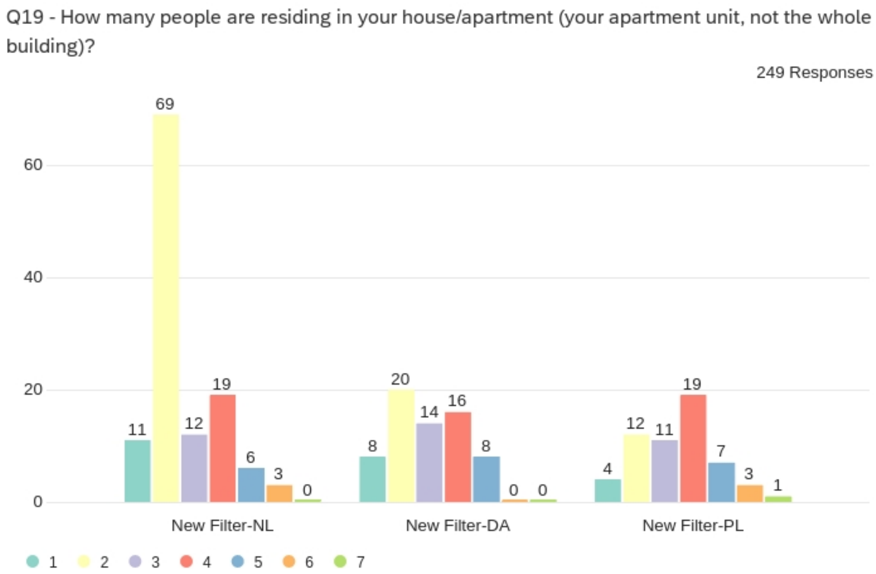


Figure 10 Numbers of household members per respondent sub-sample.

Matters relating to energy initiatives are usually discussed informally in all three sub-samples. It also seems to be the case that respondents neither perceive their social circles to consider generating energy locally as overly important nor as unimportant. Only in the Polish sub-sample is the count of respondents agreeing to this value higher than the neutral count. However, as the sample is still preliminary given that the survey was still running at the time of writing, this might still change for all sub-samples. For example, the Polish sub-sample may adapt in the direction of the other two or the other way around.

4.1.4 Building characteristics

The distribution of ***house surfaces*** in the three sub-samples show different patterns. Dutch respondents report a peak of houses with surfaces of 101-150 m² (n=57). In the Danish case, houses of 151-200 m² are most reported (n=36) and in the Polish sub-sample, we observe houses with surfaces of 51-100 m² to be most common (n=23). Houses with surfaces of 50m² and below are relatively uncommon in all three sub-samples (5% and n=6 in NL; 0% and n=0 in DK; 12% and n=7 in PL). While the sub-sample from

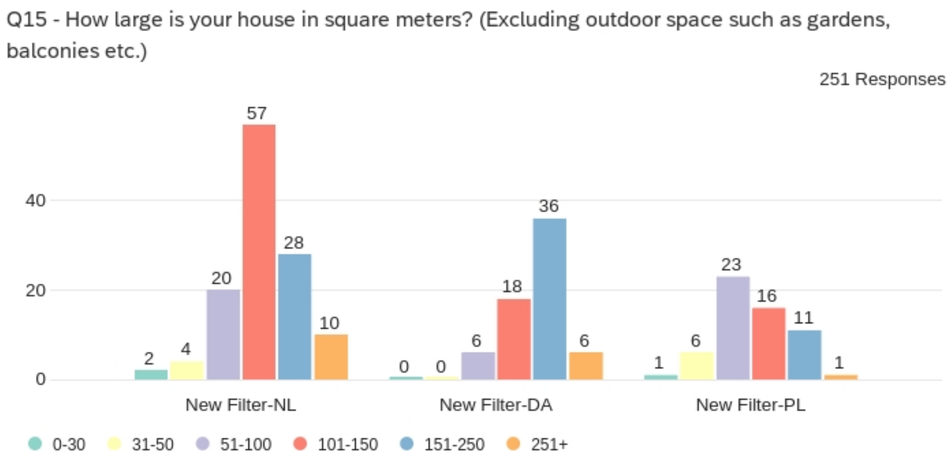


Figure 11 House surface per respondent sub-sample.

Denmark shows a distribution skewed to the larger surfaces, the sub-samples from the Netherlands and Poland show somewhat more of a normal distribution (Figure 11).

Two questions related specifically to the ***year of construction and renovation*** of respondents' homes (Figure 12). The Dutch sub-sample shows a range of 6-18 cases in most categories from before 1900 onward, including a relatively high share of buildings from before 1950 (25%, n=31). Furthermore, 35% of the Danish sub-sample respondents also own a house from before 1950 (n=23). The category of houses built between 1900-1950 is actually the largest reported on in the Danish sub-sample. In both the Dutch and Polish sub-sample, the most-reported category is that after 2010 (32% and n=39; 34% and n=20; resp.). It could be that the large share of unrenovated homes overlaps with the number of relatively newly built homes that either already had a good energy performance standard or for which inhabitants did not already want to invest again.

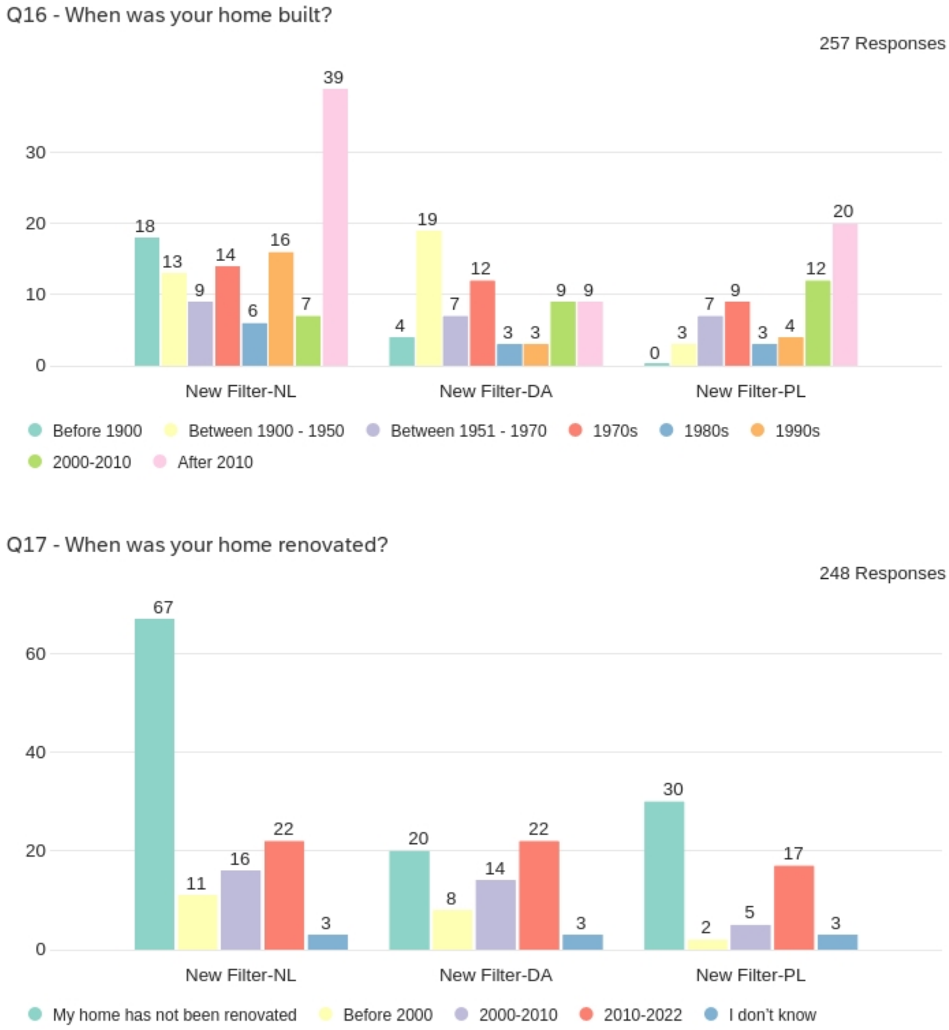


Figure 12 Construction years and renovation years per respondent sub-sample.

4.1.5 Complexity of energy uses

In a sense, this aspect is a mixed bag, as there are so many parts of daily life that energy production and use influence as well as that they are being influenced by. For example, the amount of financial resources available in a household characterise how well a household is able to invest in energy measures itself or whether it depends on external funding, such as subsidies. We observe that the sub-samples in our survey are rather different in that respect. While the Dutch and Danish sub-sample are skewed towards the higher end of the ***income scale***, the opposite is the case for the Polish sub-sample, where the lower end dominates the answers (Figure 13). Besides having the indirect impact on availability of funds to pay for energy measures, the income might also have consequences for the purpose of energy-saving measures or smartening of the local energy system as perceived by the respondents. Where households with a higher income may have a perspective of becoming more sustainable, for lower-income households increasing the energy performance of their homes might mean that there is more money left during a month to spend on things other than primary needs.

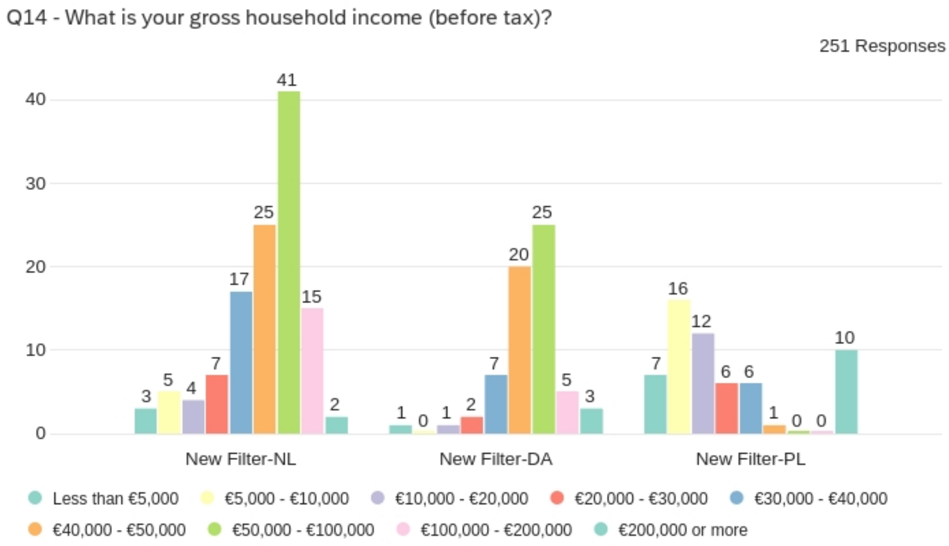


Figure 13 Household income per respondent sub-sample.

Energy is used differently by females, males, and children. Thus, some insight into the distribution of ***gender across households*** and the ***number of minors*** (aged 17 or less) is useful. Firstly, we observe that for all sub-samples, households report gender balance of the inhabitants most (Figure 14). All three histograms show an image resembling a form of a normal distribution with even the extreme ends populates with some respondents. Male only and female only households may overlap with single-households, but there are also other configurations possible, all influencing the annual energy use profile in a different way.

Secondly, a look at the distribution of minors across the sub-samples shows that we do not have too many households with minors (living at home). 77% of the Dutch households (n=91), 57% of the Danish households (n=37), and 40% of the Polish households reported not to have any minors living in the home (Figure 15).

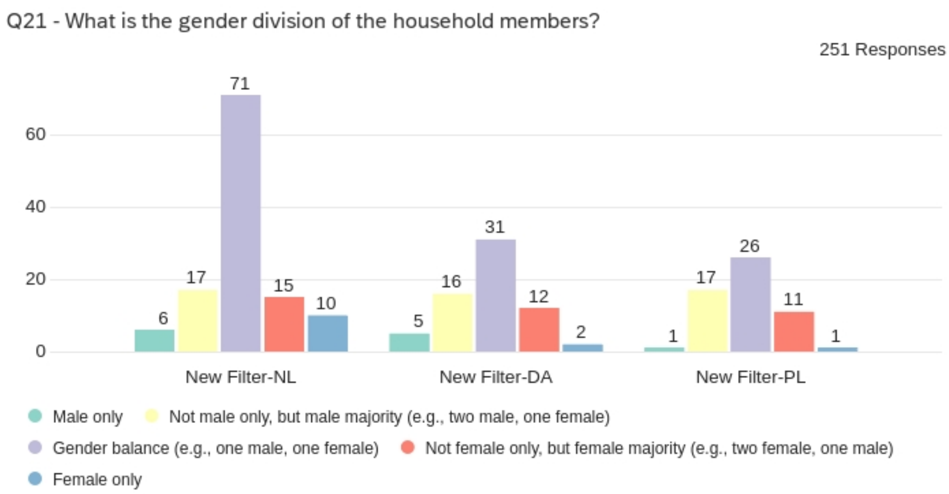


Figure 14 Gender within households per respondent sub-sample.

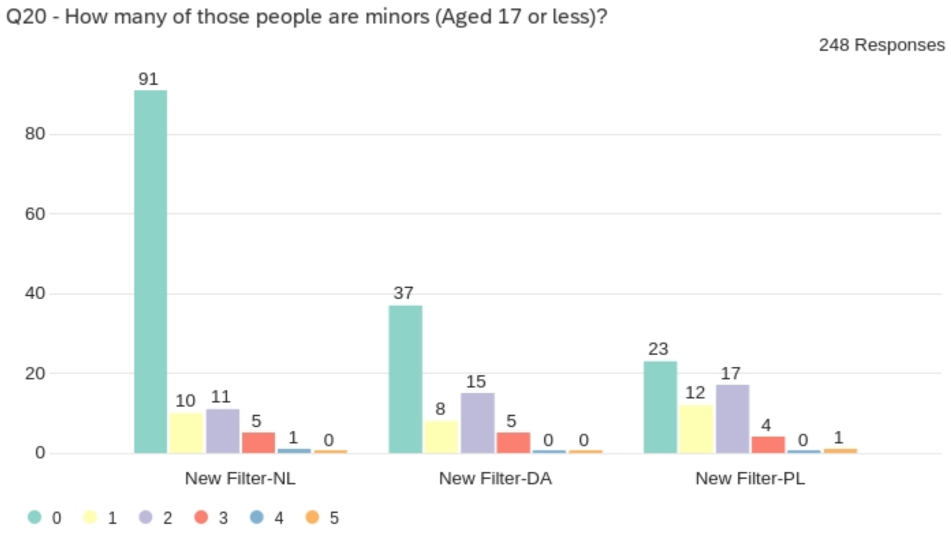


Figure 15 Number of minors in the household per respondent sub-sample.

Finally, making the local energy system more sustainable depends on a well-functioning ***interaction of households or local communities with various governance levels*** required to carry out certain technical adjustments, including the application for subsidies or permits. We asked respondents how difficult it was to interact with relevant authorities in the process of installing photovoltaics panels. The answers clearly lean to easy interactions or at worst moderately easy interactions (NL: 65%, n=24; DK: 57%, n=17; PL: 56%, n=10). Only a few respondents mentioning that it was hard to interact (NL: 8%, n=3; DK: 3%, n=1; PL: 11%, n=2).

4.2 Socio-regulatory dimensions

4.2.1 Scope of autarky

If we disaggregate the sample for each demonstrator site, we see a mixed image about the ***origin of energy initiatives is most suitably situated on the local level*** (top Figure 16). Both the Danish and Polish sites show a peak in the neutral category and decline on the agreeing end. The Polish responses are more balanced on this question. The Dutch responses are skewed towards the neutral to moderately agreeing category. We can hypothesise that there might be differences between respondents' perceptions as to who should be responsible for making the local energy system more sustainable. However, due to the low number of responses for Denmark and Poland at the time of writing, no strong comparative conclusions can be drawn about the statement.

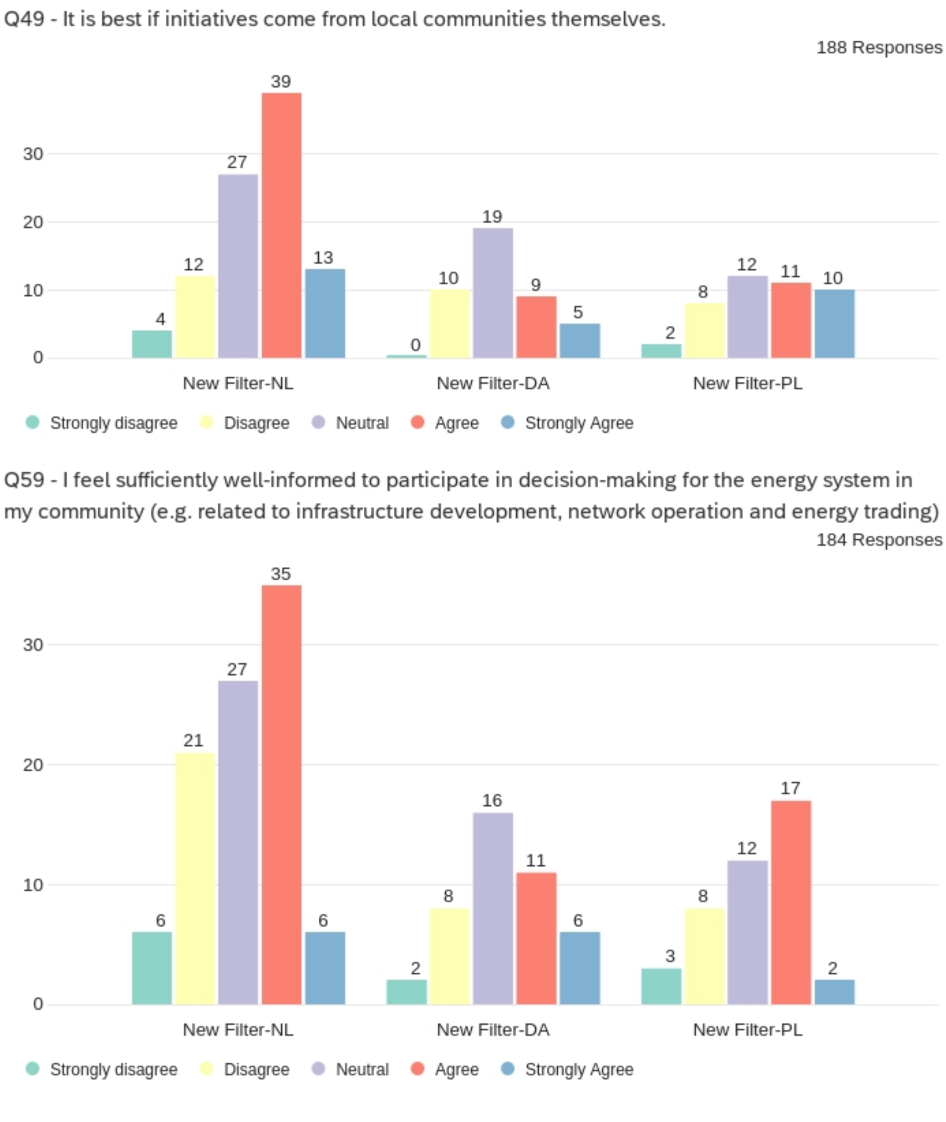


Figure 16 Origin of energy initiatives (Q49, top) and sufficiency of information for participation (Q59, bottom) per respondent sub-sample.

We assume that feeling sufficiently informed to participate in local decision-making also makes local citizens more confident about participating. Polish and Dutch respondents agree to a similar degree about feeling ***sufficiently informed to participate in local decision-making***; there seems to be a tendency towards agreement (bottom Figure 16). In the Danish answers, we observe a distribution that comes closer to a normal distribution with the highest count of respondents being neutral about the statement. Although the origin of organising local energy initiatives was not consensually perceived on the local level, respondents seem to agree to a certain extent about the fact that ***local energy demand should be covered by local production*** (top Figure 17). For all three demonstrator sites, there are high frequencies in the neutral to moderately agreeing category. Largely consistently, respondents agree that local communities should be ***self-sufficient in supplying energy and also connecting this to waste*** (bottom Figure 17). While the Dutch and Polish distributions for question 62 overlap considerably with those of question 61 (Figure 17), the Danish distribution shows a relative abandonment of the moderately agreeing category in favour of the neutral one. This allows the hypothesis that the Dutch and Polish sub-samples may treat covering local demand completely with local production as more

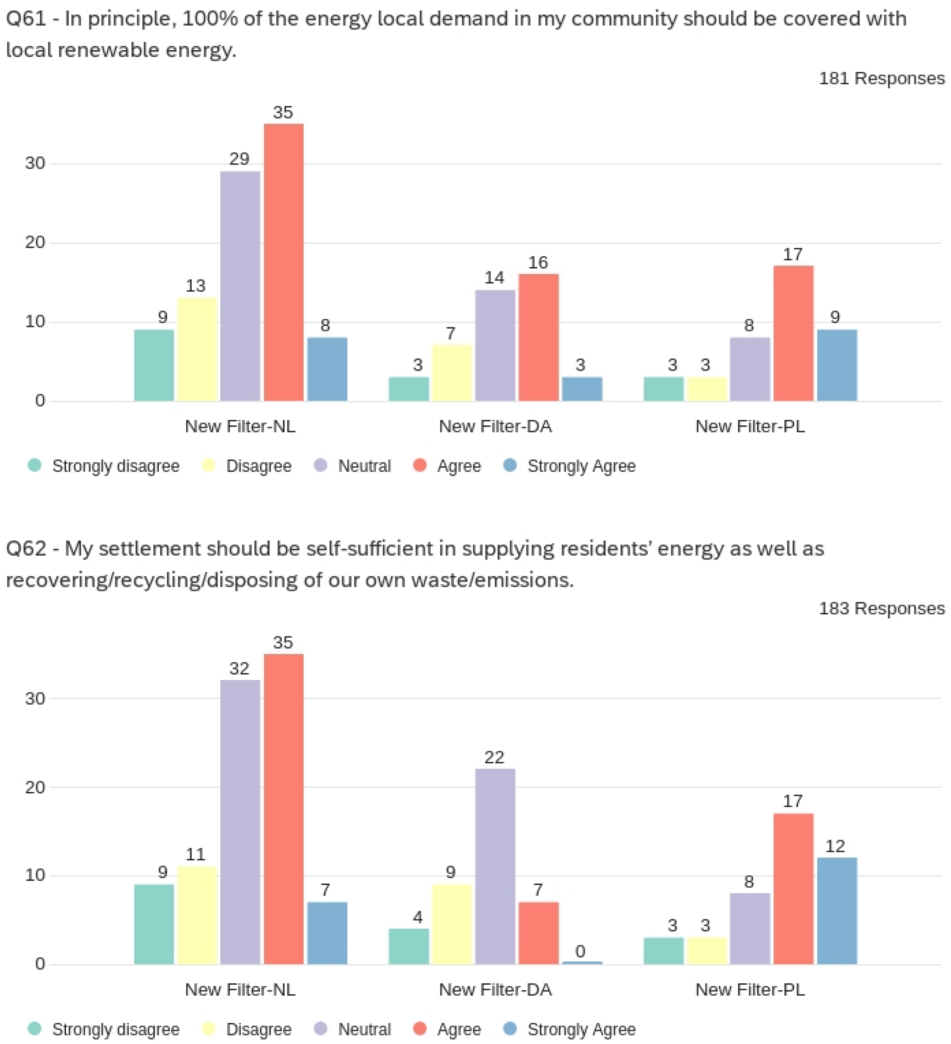


Figure 17 Locality of energy demand and production (Q61, top) and settlement self-sufficiency (Q62, bottom) per respondent sub-sample.

synonymous to being self-sufficient on the local level than the Danish sub-sample. It might also be that there is a confusion about the addition of local waste management, which would aim for a more holistic view of circularity on the local level.

When it comes to ***freedom to experiment, independence of national regulations***, and ***general energy autonomy***, we observe a mixed image (Figure 18). Danish and Dutch answers show a clear peak agreeing to a high degree of freedom to experiment, while the Polish answers are more balanced, but cautiously agreeing. Respondents are less enthusiastic about organising local energy affairs on their own, we observe more neutral answers here. While the Danish and Dutch answers shift towards the neutral category, Polish answers are more clearly skewed towards the agreeing end of the scale. There might be a difference between the acceptability of experimenting on a local level versus evolving towards becoming truly autonomous in terms of governance. Except for the Danish sub-sample, the distributions for acceptability of freedom to experiment seem consistent with those for the acceptance of initiatives coming from local level (top Figure 18 vs. top Figure 16). However, the consistency between answers about accepting local governance autonomy on energy affairs and initiatives coming from local level

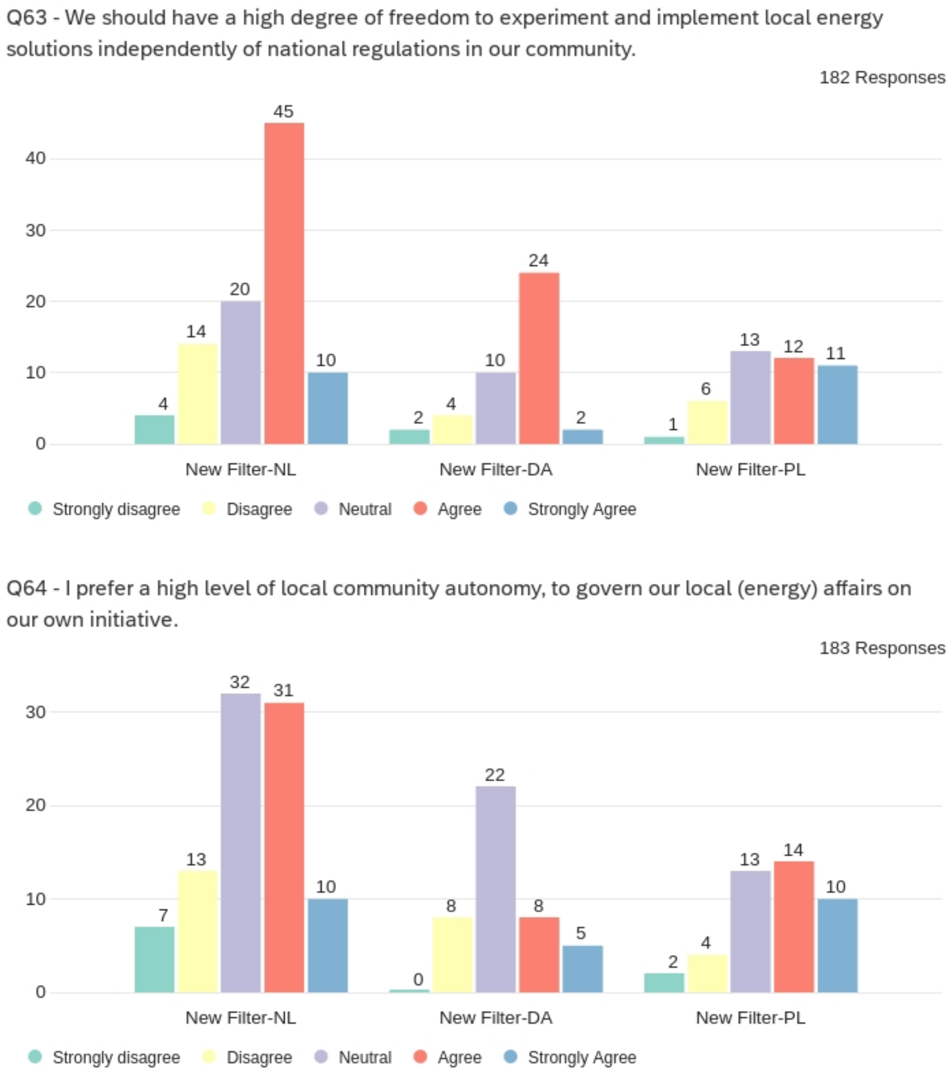


Figure 18 Freedom to experiment on local level (Q63, top) and local community autonomy (Q64, bottom) per respondent sub-sample.

seems to be higher in the Danish sub-sample than in the Dutch and Polish ones (bottom Figure 18 vs. top Figure 16). The conceptual significance and meaning of this observation still have to be further explored.

4.2.2 Alignment of energy values

The direction seems for consumers to be willing to adjust their behaviours to ensure a more efficient use of sustainably produced electricity (Figure 19). The percentage of those willing to do so is the most in the Netherlands. This may suggest that consumers are being more and more aware of the environmental crisis and are willing to take actions due to their beliefs in the importance of doing so.

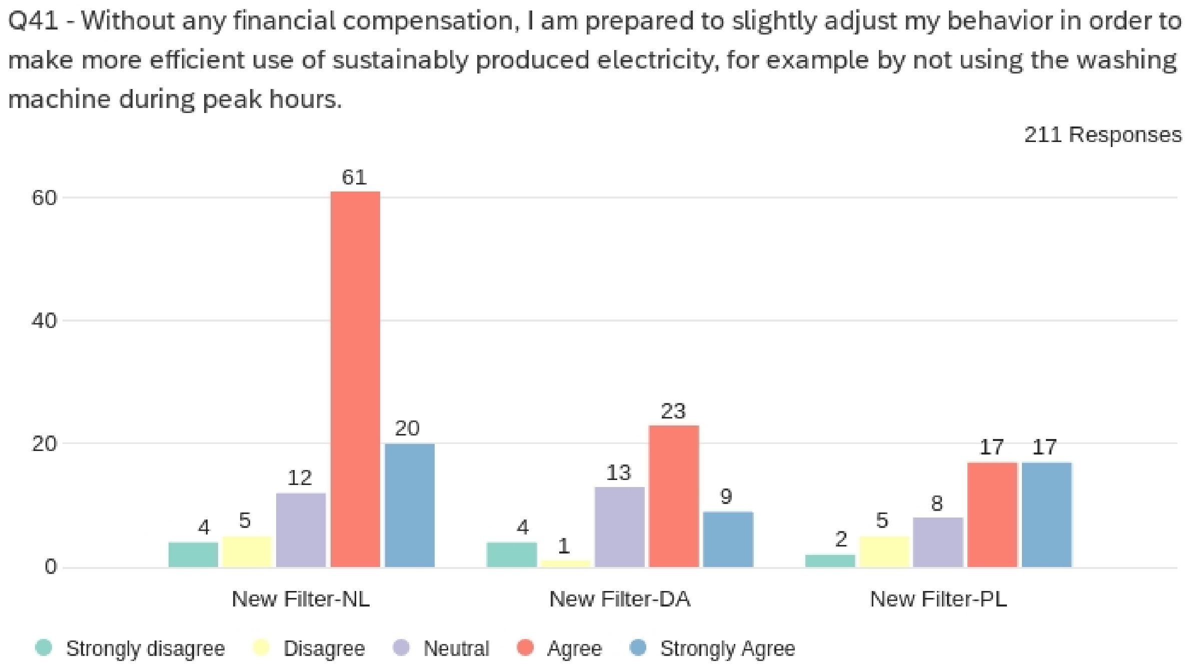


Figure 19 Willingness to adjust behaviour if it leads to more efficient use of renewable electricity.

It is interesting that residents in all the nations surveyed showed eagerness in installing a smart management system in the household to automatically reduce energy use or switch off appliances during peak hours. Still, an important number stated that either they do not want or are not sure of doing so, which implies that further work is needed on that front to ensure that more residents take initiative. Those who are not sure or are not looking to install a smart management system in the household had various reasons. Some consider that there is no need to do so. Others think it costs too much and burdensome in particular when it comes to manage it and that it restricts autonomy. In fact, they don't even see the economic rationale for doing so when it comes to profit while others connect it to whether they will own their house at one point or not considering that many rent. Many had absolutely no knowledge of it. Finally, some question the usability of these installations and long-term maintenance where many households do not consume much energy. Interestingly, there is a high consensus among those who responded stating that the production of renewables in important while very few had different opinions (Figure 20). This suggests that European citizens have embraced the idea of an energy transition in theory where renewables are becoming a favorable source of energy.

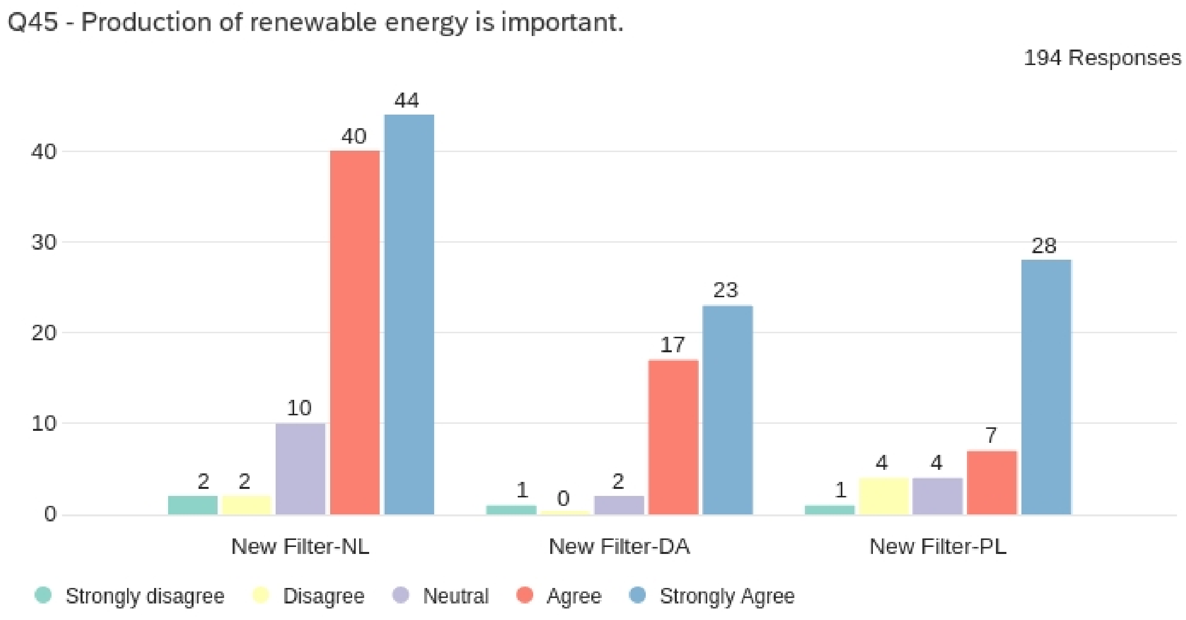


Figure 20 Importance of renewable energy production.

This also resulted in a situation where respondents from the Dutch sub-sample are willing to pay more for sustainable energy even when traditional energy sources are cheaper (Figure 21). This may suggest that the economic rationale for which citizens choose traditional energy over sustainable one is not completely precise. This is not to paint a perfect picture as numerous respondents were not able to provide a definitive answer to this suggesting that further work is needed or that may be economics and energy prices will always be relevant. This is as also a significant amount still prefer to have lower energy prices than sustainable energy.

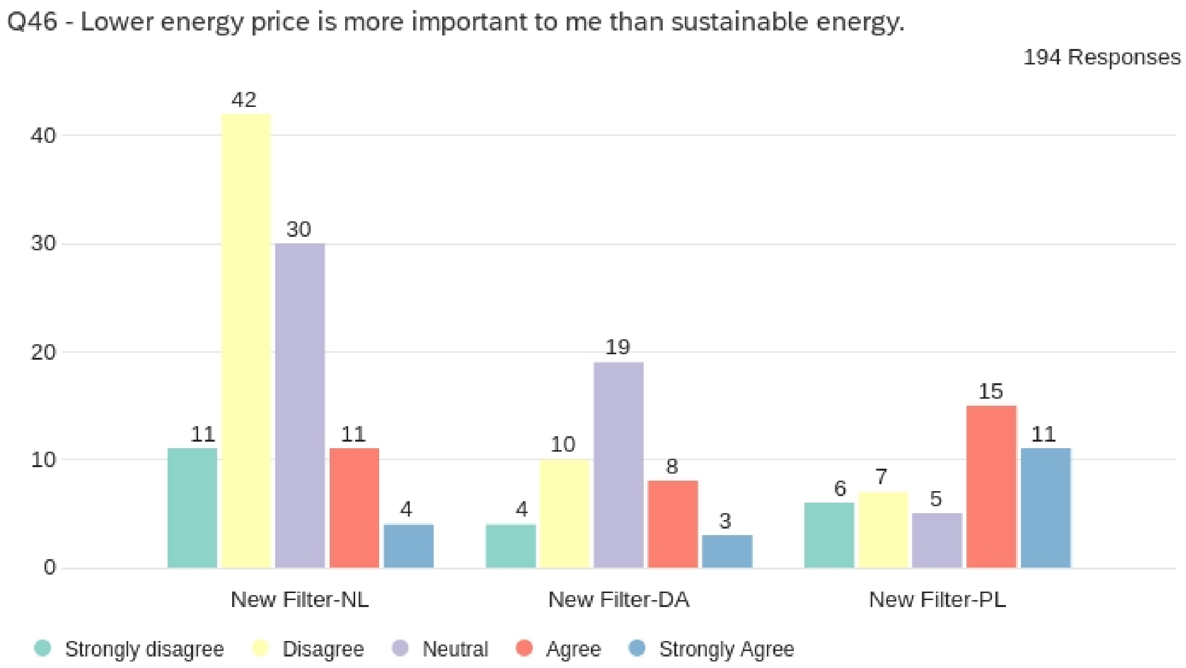


Figure 21 Trade-off between lower energy price and sustainable energy.

Interestingly and despite the support for an energy transition, a great number of respondents are against the construction of new renewable energy projects such as solar farms in their community or simply did not have an opinion on this. This is especially the case in the Netherlands where residents disagreed with this or were neutral. Still, the majority supported such construction. Hence, one would wonder about the factors that lead citizens to object over the building of renewable energy projects in their communities. Overall, people seem to think that national government policies support centralized power sources or make it difficult to have decentralized systems (Figure 22). Some are confused as to what exactly national government policy entails with regards to backing decentralized power sources while others have different opinions. As such, it seems that the government in the countries surveyed is seen in a bad light when it comes to pushing towards further energy decentralization.

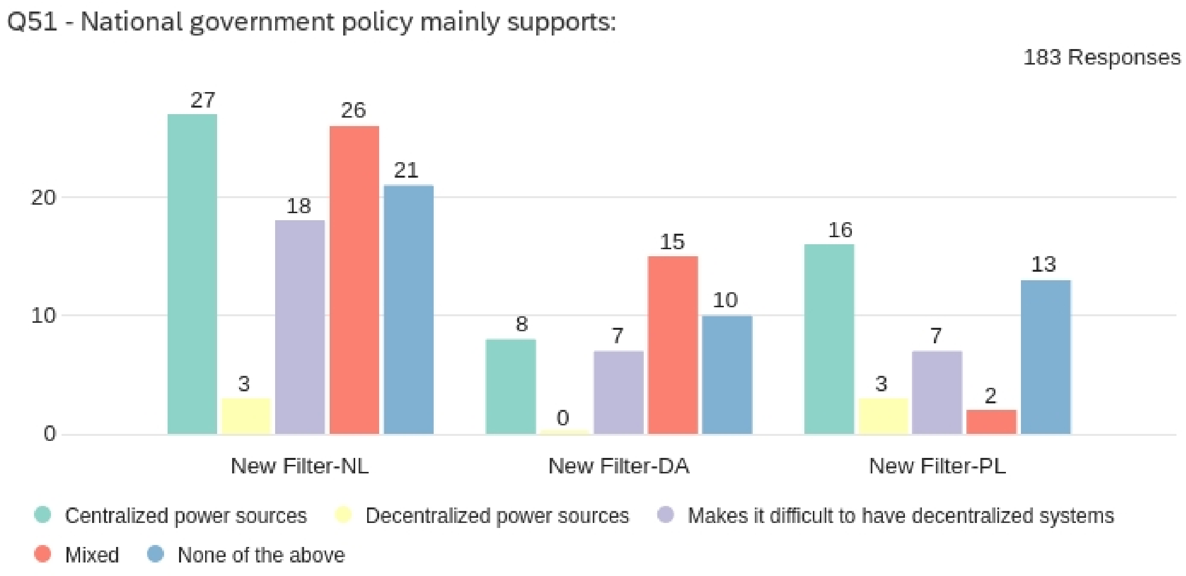


Figure 22 Role of national government policies.

Overall, there is an agreement that saving energy is an important value in one's social circle or network. What is concerning is that a large proportion of citizens are not sure whether saving energy is an important value or not. It is not clear from the survey as to why this is the case. One can only assume that potentially it is a lack of awareness of the importance of saving energy. In fact, numerous citizens found that climate change in their immediate surroundings such as home or neighborhood is an important factor in making energy related decisions. Yet, again, many had no clear opinion on this issue which makes one wonder about their awareness of the eminent danger coming from climate change. Finally, a majority of citizens agreed that their communities should be able to share and store energy and rely on the national energy system as little as possible (Figure 23). This is an interesting finding when one considers that earlier citizens thought that the governments are not pushing towards energy decentralization. One would wonder how this would play out in the future. But also in this case, many remained neutral.

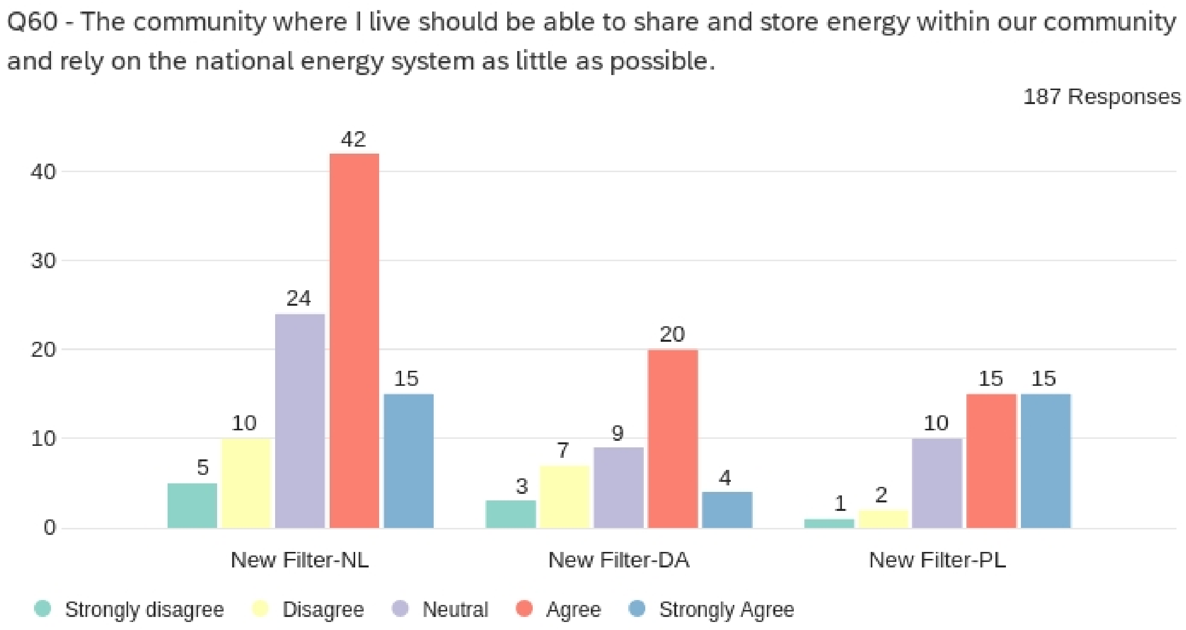


Figure 23 Local storing and sharing energy and national grid reliance.

4.2.3 Formal self-governance

Self-governance largely refers to autonomous decision-making by the local community on energy topics, including generation, storage as well as distribution of energy. The extent to which communities wish to self-govern local energy projects as envisioned in SERENE can be measured based on three questions in the survey.

First, we questioned whether Danish, Dutch and Polish citizens think it is best if energy initiatives come from local communities themselves. We see similar patterns across respondents in the Netherlands (n=95) and Poland (n=44) of which a majority (strongly) agrees with this statement (resp. 55% and 50%). Whilst of Danish respondents (n=43) the majority does not seem to have an opinion in this regard and answered neutral to this question (44%) (Figure 24). This indicates that in the Netherlands and Poland there is a predominant belief that local energy projects should be set up by the local community itself, rather than other stakeholders such as project developers and local or national public actors. In Denmark the citizens are less outspoken about who should set up local energy projects.

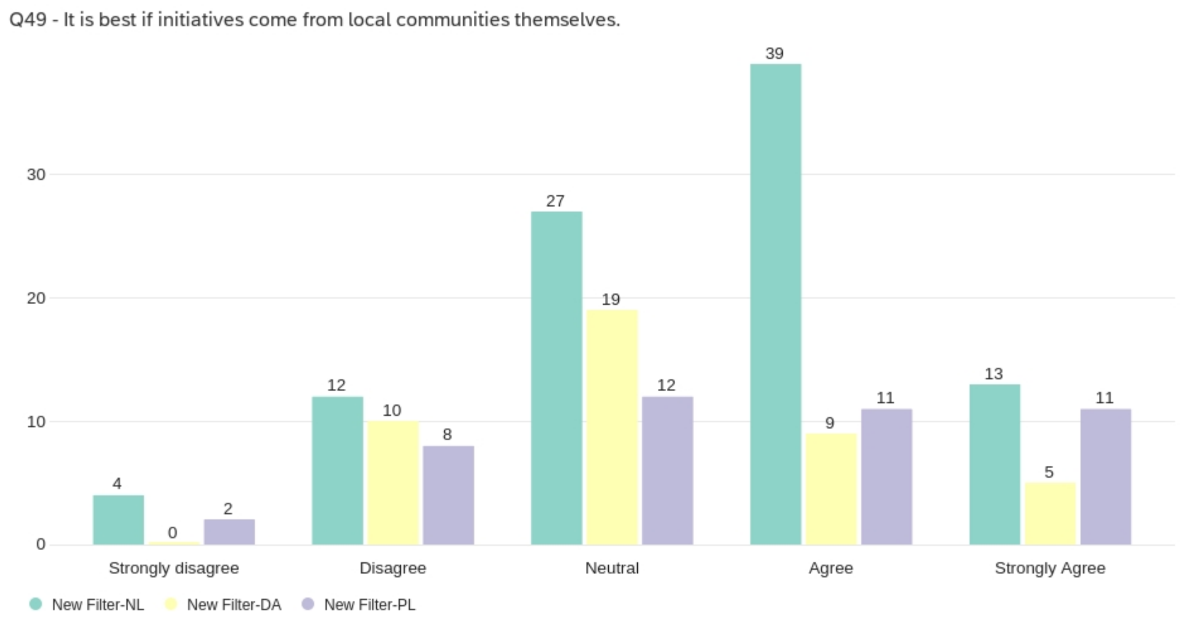


Figure 24 Preference for local initiatives.

Second, we asked – once such local energy projects are set – who should be taking the decisions? Dutch (n=161) and Danish (n=81) respondents show similar preferences in this regard. They prefer the local government to take decisions (resp., 34% and 30%) and otherwise local residents are the second-best option (resp., 30% and 26%). This is preferred over the national government and local or regional utilities, but especially over private companies as the least preferred option. The order of preference for Polish respondents (n=59) is similar, however, they show an even stronger preference for local governments to take decisions (46%). This indicates that in the Netherlands, Denmark as well as Poland there is a predominant belief that decisions on local energy projects should be taken by local governments and residents. This indicates that in the Netherlands, Denmark and especially Poland there is a predominant belief that decisions on local energy projects should be taken by local governments (Figure 25).

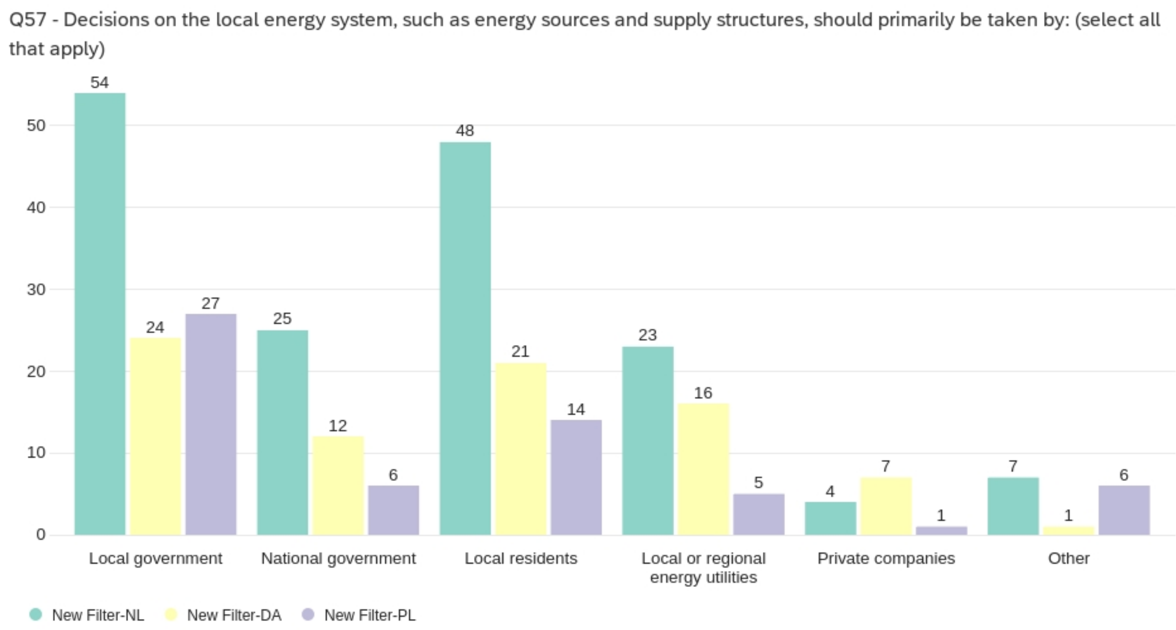


Figure 25 Who should take decisions about the local energy system.

Finally, we asked whether respondents feel like energy production should be more locally controlled. In comparison, Polish respondents (n=44) show the largest share of 52% who either agree or strongly agree on this statement. Dutch respondents (n=93) similarly show that a majority of 44% would like their energy production to be more locally controlled. For the Danish respondents (n=43), the pattern is somewhat different, as the majority of 37% is neutral in this regard and the remaining respondents almost equally (strongly) agree or (strongly) disagree on this statement. Hence, where Dutch and Polish show a stronger conviction that energy production should be more locally controlled, Danish respondents are less outspoken as with the first question asked (Figure 26).

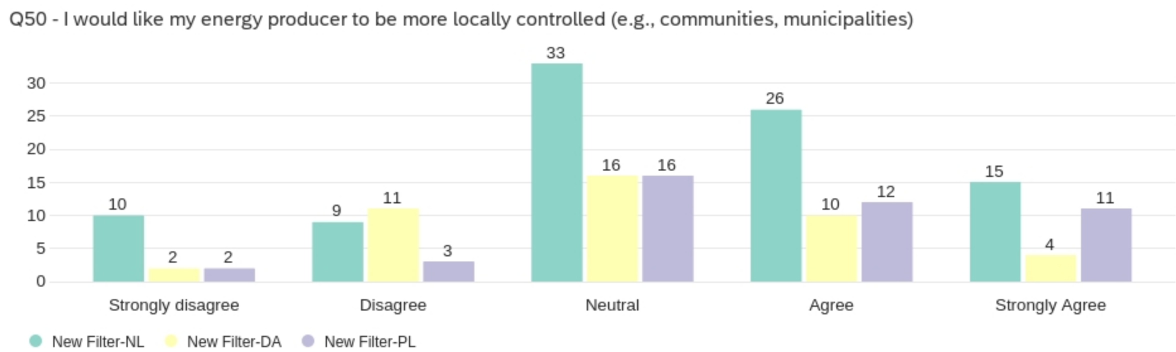


Figure 26 More local control of energy producer.

In sum, even though the Dutch respondents show a slight stronger preference for self-governance, the Polish respondents are very much alike; they would like local energy projects to come from local community itself and energy production to be more locally controlled, though once this is set up, they prefer local governments to take decisions. Danish respondents are less outspoken when it comes to local control over energy production and the setup of energy initiatives by the local community, though they similarly prefer local governments to take decisions.

4.2.4 Energy and land regulations

Citizens in Europe pay different price for electricity per year depending on their level of energy consumption and efficiency. This can be noticed in the Netherlands, Denmark, and Poland. In some cases, there are even stark differences in the amounts being paid which may imply different financial capacity for each household. It is not clear however, how this difference affects the view of different households with regards to energy consumption. Majority of respondents have installed heat pumps in their houses followed by solar heating, wind turbines and biomass furnace, with photovoltaics systems included in the "other" category (Figure 27). Meanwhile other unspecified devices were also installed to a greater degree including Photovoltaic systems. For the time being, it seems that heat pumps are the most favourite, one would wonder whether other devices will become as important in the near future.

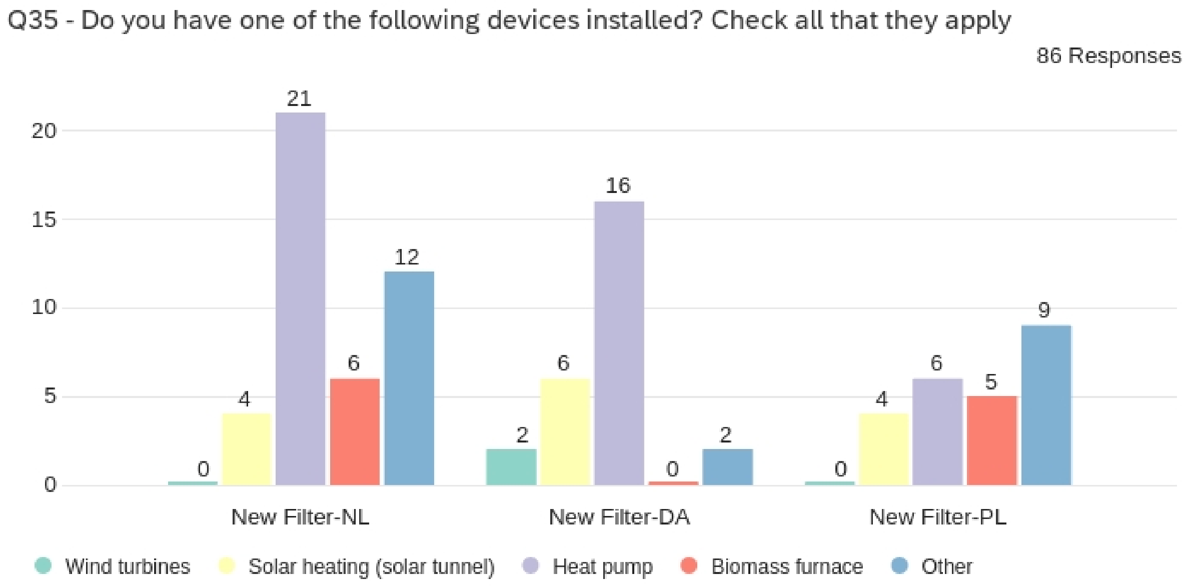


Figure 27 Installed devices.

A large number of respondents are not willing to pay extra to ensure that their energy is coming from renewable sources (Figure 28). Those who are willing to pay were mainly interested in doing so between 5 to 10% more followed by 1 to 5% and then 10 to 15%. Interesting, in the Netherlands, a significant amount was willing to pay between 10 to 15%. One cannot blame citizens, if they are not willing to pay more especially if they are considered poor households. Rather, one would suggest the government to provide additional support to them in this regard. Still, this contradicts the responses to the question of whether lower energy prices are more important than having sustainable energy sources where respondents replied negatively. One can only assume that citizens would put the responsibility of that on governments and not households.

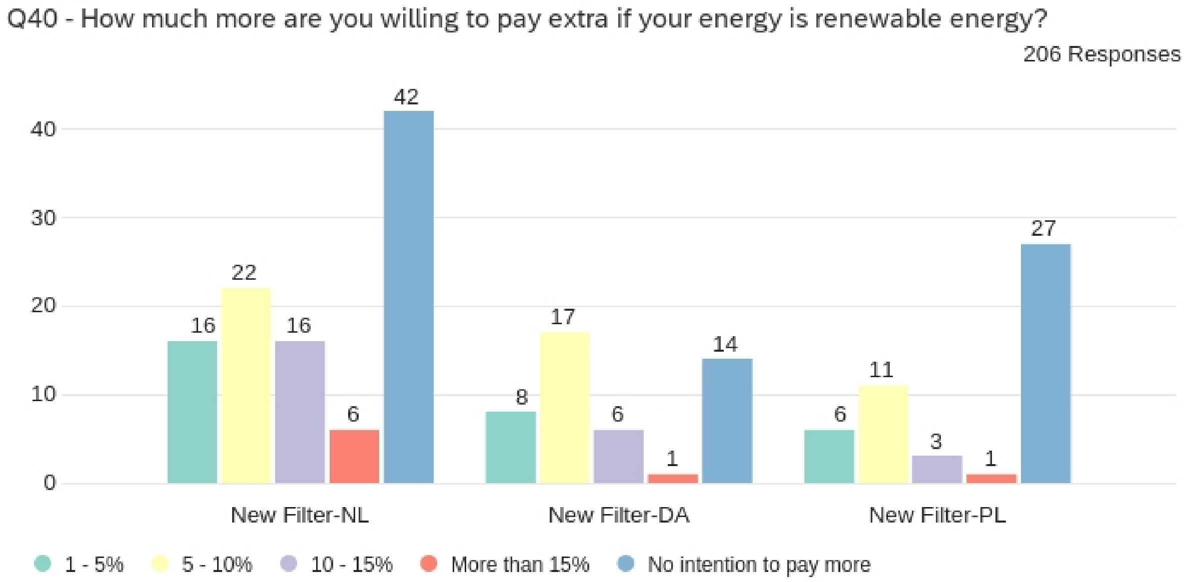


Figure 28 Willingness to pay extra for renewable energy.

The majority of citizens agreed that energy production need to be more locally controlled via for instance communities and municipalities (cf. Figure 26). What is interesting is that also plenty of people were not sure about this issue and did not provide a positive or a negative response. What is more, in the Netherlands and Denmark, many disagreed with the production of energy locally which may imply that they don't trust the local communities and municipalities to fulfil this task or potentially that they see the central government as more efficient.

Finally, respondents feel sufficiently well-informed to participate in decision-making for the energy system of the community such as those related to infrastructure development, network operation and energy trading (Figure 29). This in contrast to a great number of people who remained neutral or disagreed with regards to this question. This can explain their active agreement and disagreement over the various matters they were asked to provide an opinion on and over energy issues generally.

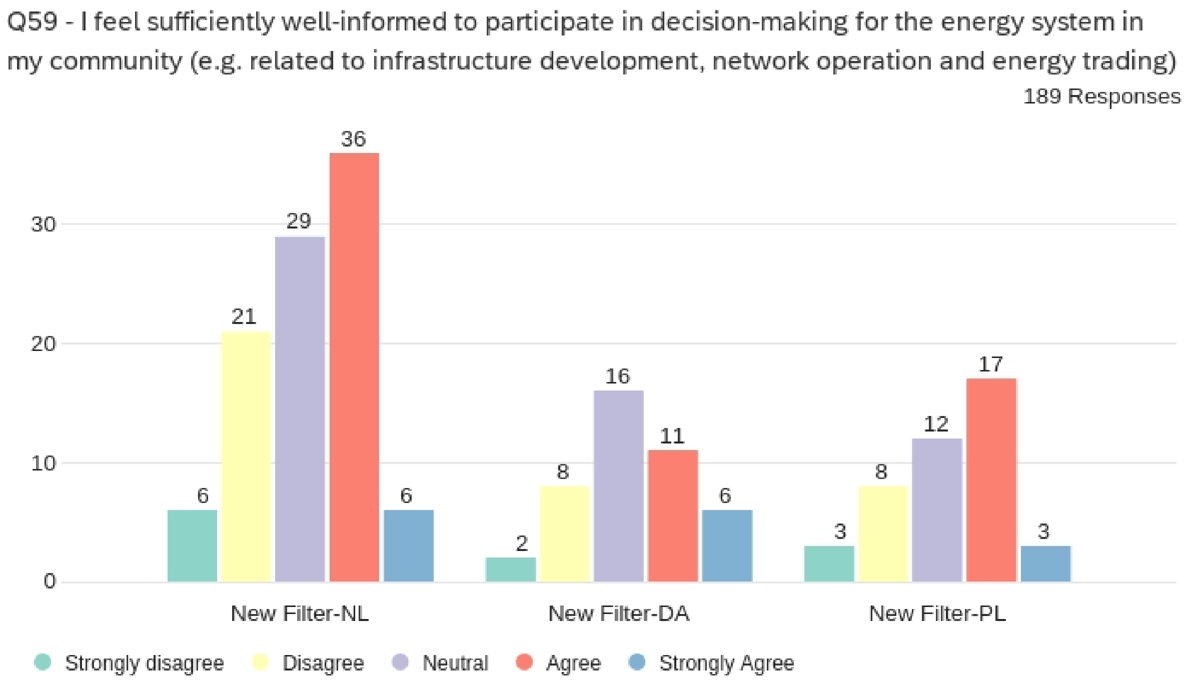


Figure 29 Feeling of being informed sufficiently to participate in decision-making.

4.2.5 Social Organization

Majority of respondents live in rural areas in the Netherlands and Poland while in Denmark, many did not specify the location. Meanwhile, many have mixed residences. This likely affects the perception and overview with regards to the various issues asked. One would wonder whether the responses would have been different if more people from the city responded. Interestingly, a great number of residents are not a member of a local association nor are active in their communities. This is not to say that there aren't those who are. Majority of people are active in local associations related to the environment (Figure 30). In the second place comes the infrastructure/neighbourhoods association where more people are involved in these in Denmark. Finally, those related to buildings and construction come in the third place. What is interesting that many residents are active in other types of associations. What is more, the level of involvement in each theme mentioned above varies between countries reflecting perhaps different citizens priorities and way of thinking.

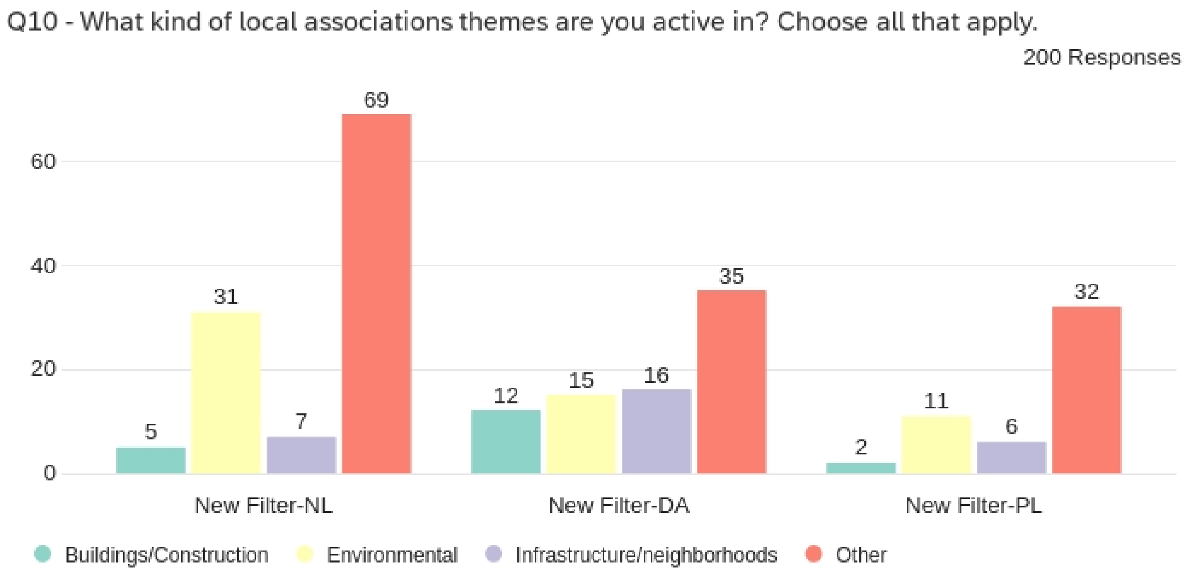


Figure 30 Activity in local associations.

Energy matters are discussed primarily with regards to home private spaces (Figure 31). The neighbourhood or building's common spaces was the second one debated then public municipal spaces. This result makes absolute sense as citizens are first concerned with home private spaces, then the neighbourhood and finally the public municipal spaces. One would wonder whether there is a need to put further emphasis on the second and third layers. It is worth mentioning that many do not discuss energy matters with their neighbors.

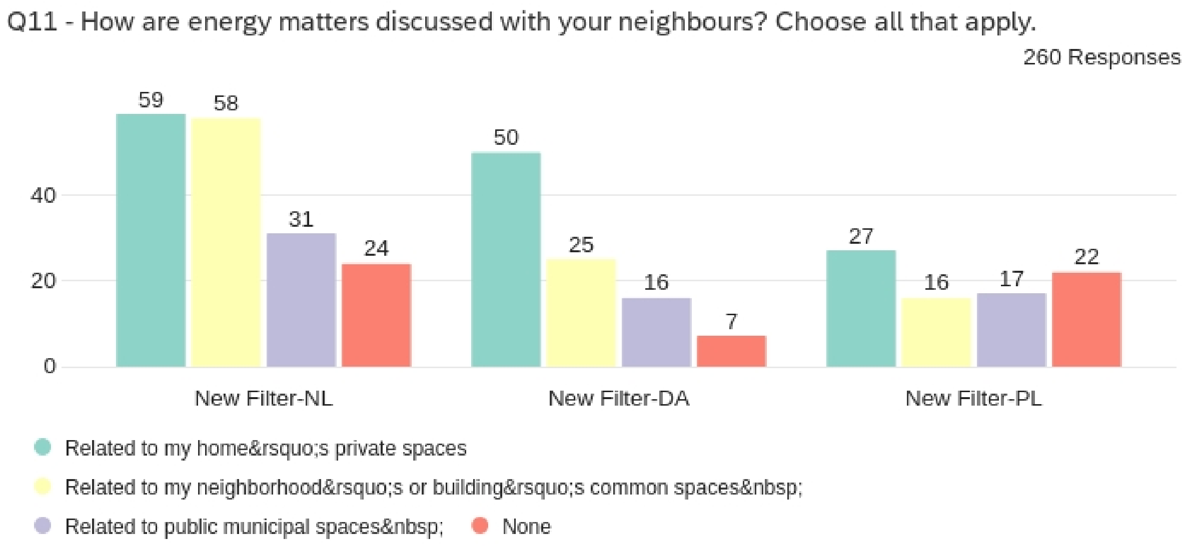
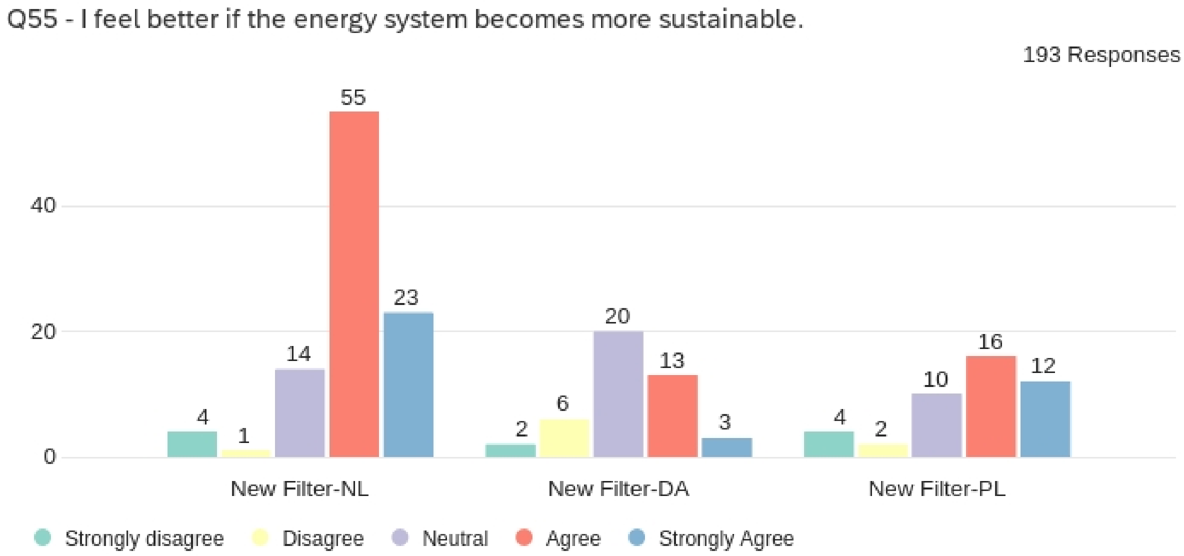


Figure 31 Ways of discussing energy matters with neighbours.

Majority of citizens in Netherlands and Poland agreed that they would feel better if the energy system becomes more sustainable (Figure 32). What is concerning is that a huge proportion especially in Denmark are neutral when it comes to this issue which implies that more work is needed on that front. One potential explanation to the situation in Denmark is that the country is already quite sustainable.

For instance, in 2021, 72% of all electricity consumed in Denmark was derived from renewable sources (Energistyrelsen, 2021).

Figure 32 Preference for more sustainable energy systems.



Decisions on the local energy system, such as energy sources and supply structures should be taken by the local government then the local residents (Figure 25). Local and regional energy utilities and national governments came later on as responses. Finally, private companies are seen as the last choice in this regard. This highlights potentially citizens distrust in the central government but also their willingness to take an active role in energy decentralization for various reasons.

5 Discussion: social acceptability of energy autarky & consumer types

5.1 Social acceptability of energy autarky

Based on the survey results, one can notice that several factors affect the acceptability of energy autarky by consumers and communities in general. These are: 1) energy decentralization; 2) citizens awareness; 3) political issues; and 4) economic reasons.

Energy decentralization refers to the production and consumption of energy at the community level without reliance on states as the traditional provider of such a service. Citizens around the world are embracing this approach especially in Europe given that it is supported by various EU directives, acts and guidelines (Heldeweg & Saintier, 2020). This seems to affect mainly the electricity sector at this stage although many other fields are expected to follow (Hess & Lee, 2020). This global phenomenon will not stop any time soon especially when one considers that the state in many places does not have the capacity to provide such service efficiently (Khan, 2020). This is also further accelerated by the advent of digitalization (Wu et al, 2021), where technologies such as blockchain and Internet of Things are being used (Esmat et al, 2021; Casquico et al., 2021). Based on the results of the survey, it seems that citizens embrace the concept of energy autarky at the local level to a certain extent since it provides them with the capability to have a say but also be energy independent: it might provide a sense of comfort knowing that as a citizen you get to make very relevant decisions related to your survival. However, while the tangible changes relating to the introduction of (smart) sustainable energy technologies are a welcome change and experimentation is appreciated, respondents in our sub-samples seemed more reluctant to deal with the governance that would come along with *really* doing everything autarkically (cf. Figure 18). This is one of the main reasons for which one would go for energy decentralization embracing at least physical-technical energy autarky. Challenges remain however, as simply doing so does not guarantee the success communities overall in their quests as the state may need to intervene. This is especially the case when one considers that the citizen's immediate concern is the household and not the community which may lead to free riding. However, the general direction is towards energy generation and consumption at the local level where exchanges among communities would take place when in need.

Awareness of the need to make an energy shift can be considered as one of the highlights of the survey as various questions we asked point in that direction. This shows the constant changes in the values of citizens across European countries where factors such as sustainability and energy efficiency are becoming more important. Such change is also reflected in other European countries such as Finland (Vainio et al., 2019). Moreover, grassroots initiatives are playing an important role in this context (Blanchet, 2015). Still, understanding this change is not easy given the need to consider various factors including psychological ones (Hamann et al., 2023), where such involvement is very complicated given that many actors have a role and say at the same time (Beauchampet & Walsh, 2021). This is not to say that there are no local oppositions to the developments taking place especially when local rights and entitlements are at risk (Lennon, Dunphy, & Sanvicente, 2019). As highlighted in the survey, citizens are aware of most of the elements in relation to energy transition and are following the developments taking place in this field. What is concerning is that in many cases, they either responded by being "neutral" or stating, "I Don't Know". This implies that despite the efforts made, numerous citizens remain uninformed with regards to energy transition topics in general or specific elements associated with it. As such, further efforts are needed at the various levels to ensure that citizens are aware of the impact of their behaviour on the energy transition as well as all the elements associated with this topic which might push them to become further involved. This is already happening as even those who are very sceptics are seeing an opportunity in getting involved in this field regardless of their motives to do so.

Politics is also an important factor in the energy transition. This is why, the term “Politics of Energy Transition” has emerged in the literature (Aklin & Urpelainen, 2018) while organizations such as the International Energy Agency are constantly making projections about the future of this field (Carrington & Stephenson, 2018). This is not a new phenomenon as politics and energy were always interlinked in the last century. Moreover, conflicts such as the Russian-Ukrainian war might have affected citizens perception of energy resources and the importance of generating it locally. This to reduce dependence on other states and factors that are out of their control especially when one considers the rise in energy prices because of this. This created a new type of political dynamic where a clash may occur between states and locals when it comes to decision-making power as a result of energy decentralization (Rignall, 2015), especially as social planning remains important for achieving a proper transition (Miller & Richter, 2014). In fact, already political coalitions are in place playing a role in the energy transition debate (Hess, 2019). All these elements were seen from citizens responses in the survey. The shift towards renewables was driven by the need to have control over one’s energy resources to avoid any potential disruption emerging because of conflicts mainly in this case the Russian-Ukrainian war. This created political sensitivities at the national level as the direction is towards a reduced trust in the state ability to provide energy and rather more focus on the local level and capabilities. Hence, the social acceptability of energy autarky is connected to citizens’ need to be energy independent from a political perspective. Only time will tell whether would result in serious clash at the national level between state agencies and local communities once local energy production becomes the status quo.

Finally, despite the economic situation, citizens are embracing the shift towards renewables for various reasons including energy independence and lowering the prices of energy. The general assumption held in the literature is that citizens due to economic reasons are not willing to take concrete actions to participate in energy transition. Respondents in the survey showed a different trend. Citizens in fact are willing for instance to pay more for sustainable energy, are willing to use energy efficient measures and overall spend more on energy resources if it leads to a better environment. That is in stark contrast to the views held just few decades ago. Does that mean that economics and energy prices are no longer a factor in the equation? On the contrary, they remain an important element and will remain as such in the future. Another reason for the shift is the possibility of benefitting financially from renewable energy especially when one considers the support schemes offered by the states to that end. It is important to mention here that this result can only be seen in the European context and not generalized elsewhere especially in developing countries. However, it contradicts the traditional assumptions held previously. One can only wonder about the reasons for which this took place. In fact, further research on this phenomenon is needed considering the context, geography, the political system among many other things. Furthermore, one need to consider the role of the state in this regard, for instance in this case in the Netherlands, Denmark and Poland.

The combination of all of these factors together provides a possible understanding of how the responses to the survey came about. It is worth mentioning that the responses received as sufficient to make a set of assumptions but not providing a generalization with regards to the entire debate concerning local energy systems. The authors are working on increasing the sample size based on which more tangible outcomes can be made.

5.2 Types of consumers

As our sub-samples are too divergent in size that we could make strong comparisons between them, we have to present preliminary insights into the characteristics of energy consumers concerning energy autarky and can only discuss these in relation to each sub-sample separately. Furthermore, the types of consumers per sub-sample that we can distinguish cannot be generalised or taken for granted as existing on a larger scale, even within each country. A typology of consumers is only based on the sub-sample and its alignment with other empirical contexts has to be tested in different circumstances.

5.2.1 Gdansk region, Poland

The physical-technical dimension in the Polish sub-sample is characterised by abundant green and water elements. Many respondents live in smaller-size (51-100 m²), self-owned, detached houses that are young and for now unrenovated. Most households in the sample are composed of four persons who are balanced in gender. There are some renewable energy prosumers, but a majority is currently not willing to install new photovoltaic panels, perhaps, because most households are at the lower end of the income scale. Installing photovoltaics is perceived as too expensive or not possible for those respondents who do not own their house. It is, therefore, not surprising that many are willing to change their behaviour slightly to save money.

The socio-regulatory dimension in the Polish sub-sample is characterised by a considerable alignment of energy values. There was mostly agreement that behaviour change would be an option, that renewable energy production is important, that a low energy price would be preferred over a higher price for renewable energy, and that it should be possible to store and share locally produced energy on the local level. In general, local governments and residents were preferred to be in charge of energy affairs, including slightly more control over the energy producer. There seems to be a general feeling that one is sufficiently well-informed to participate in decision-making. Surprisingly, respondents in the sub-sample were more neutral about where energy initiatives should originate. Polish respondents are quite clear that they would like to cover all local energy demand with local production, which should lead to energy self-sufficiency and a more sustainable energy system. They prefer a renewable energy price at most equal to the current price. They would also like to experiment to a certain extent, but governing energy affairs is less enthusiastically received. Polish respondents engage mostly in associations other than environmental, infrastructure, or buildings (in that order). The topics they discuss relate to various types of spaces in a balanced way.

5.2.2 Skanderborg region, Denmark

The physical-technical dimension in the Danish sub-sample is characterised by abundant green and water elements. Many respondents live in mid- to large-size (151-250 m²), self-owned, detached houses that are relatively old and renovated during various periods. The majority of households in the sample is composed of two persons who are balanced in gender, but with few minors only. There are some renewable energy prosumers with a middle income. Installing photovoltaics is perceived as too expensive. Many are willing to change their behaviour slightly to save money.

The socio-regulatory dimension in the Danish sub-sample is characterised by a considerable alignment of energy values. There was mostly agreement that behaviour change would be an option, that renewable energy production is important, and that it should be possible to store and share locally produced energy on the local level. A majority was neutral about whether a low energy price would be preferred over a higher price for renewable energy. In general, local governments and residents were preferred to be in charge of energy affairs together with local/regional energy utilities. There seems to be a general feeling that one is sufficiently well-informed to participate in decision-making. Surprisingly, respondents in the sub-sample were more neutral about where energy initiatives should originate. Danish respondents are quite clear that they would like to cover all local energy demand with local production but are relatively neutral about energy self-sufficiency and a more sustainable energy system. They either prefer a renewable energy price at most equal to the current price or are willing to pay a bit more. They would also like to experiment, and governing energy affairs is similarly important. Danish respondents engage mostly in associations other than infrastructure, environmental, or buildings (in that order). They mostly discuss topics related to their homes and private spaces.

5.2.3 Olst-Wijhe region, The Netherlands

The physical-technical dimension in the Dutch sub-sample is characterised by abundant green and water elements. Many respondents live in mid-size (101-150 m²), self-owned, semi-detached or detached houses. Most of these houses are relatively young, but there is also a large share of old and very old buildings. Many houses, presumably the younger ones, are unrenovated. The majority of households in the sample is composed of two persons who are balanced in gender without minors. There are many renewable energy prosumers with a middle income, who are mostly willing to change their behaviour slightly to save money. The barriers to installing photovoltaics are unclear, perhaps, because there is already a high share of prosumers who would not require additional photovoltaics anyway.

The socio-regulatory dimension in the Dutch sub-sample is characterised by a considerable alignment of energy values. There was mostly agreement that behaviour change would be an option, that renewable energy production is important, and that it should be possible to store and share locally produced energy on the local level. A majority did not prefer a low energy price over a higher price for renewable energy. This contradicts the fact that a majority is not willing to pay more for renewable energy. In general, local governments and residents were preferred to be in charge of energy affairs, including more control over the energy producer. There seems to be a general feeling that one is sufficiently well-informed to participate in decision-making. Respondents in the sub-sample appreciated energy initiatives originating on the local level. Dutch respondents are quite clear that they would like to cover all local energy demand with local production, which should lead to energy self-sufficiency and a more sustainable energy system. They would also like to experiment, but governing energy affairs is less enthusiastically received. Dutch respondents engage mostly in associations other than environmental, infrastructure, or buildings (in that order). They mostly discuss topics related to their homes and private spaces, as well as related to the neighbourhood or common space.

6 Conclusions and Outlook

The good news is that the future does not look bleak. The bad news is that further efforts are needed to ensure that the needed results are achieved. Indeed, citizens in our survey sample seem to embrace the energy transition, in this case in the context of energy autarky. They are taking initiatives, making plans and using their own financial resources to ensure energy independence at the household and community level. Still, to mitigate climate change, more citizens need to embrace this trajectory. Further research is needed that relies on larger samples to understand the extent to which energy autarky is indeed implemented within European countries at the community level. The main highlights of the report are the following:

- Energy transition is underway in European countries as a result of the initiatives of citizens due to various factors.
- Social acceptance of the transition and energy decentralization is high and is expected to further grow as citizens witness its positive consequences.
- New political situation is created due to this development requiring further studies to prevent future clashes between the state and local communities investing in renewable energy.
- Economics in terms of energy prices for instance no longer have the final say in deciding whether a citizen invests in renewables or not.
- Citizen awareness has increased, allowing such change although more efforts are needed in this regard.

Furthermore, we notice a difference in types of consumers between the regions in which the SUSTENANCE demonstrator sites are located. While economic reasons are often a strong reason to invest in or at least be interested in a more sustainable local energy system, there are also consumers who are perfectly willing to pay more for renewable energy, i.e. taking a decision that is at face value economically irrational, but more prompted by concerns over sustainability. Nevertheless, in each sub-sample, we have seen a considerable alignment of energy values suggesting that there is a potential for constituting communities that might be willing to at least work on physical-technical energy autarky, if not also on socio-regulatory energy autarky. Once again, the size and demographic structure of our sample indicates that we have a relatively limited picture of each country's society, which requires broader coverage and method triangulation in the future.

These results are also supported by part of the literature focusing on energy autarky and independence. Hence, the research conducted in this report adds to the existing body of literature in this context creating an added value by addressing energy autarky via 10 dimensions:1) alignment of energy values; 2) formal self-governance; 3) energy and land regulations; 4) social organizations; 5) technological dependency; 6) local renewable energy sources; 7) settlement characteristics; 8) building characteristics; 9) complexity of energy uses and 10) scope of autarky.

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Annex A: Sorted list of survey questions

	Q#	Question
Physical-technical dimensions		
Technological dependence	Q23	Do you use green or renewable electricity?
	Q29	Does your electricity supplier offer different tariffs for electricity depending on the time of day, for example at night ("off-peak" tariffs)?
	Q30	Does your household use a smart meter to record electricity use?
	Q31	Do you charge your electric vehicle at home?
	Q32	Do you have solar panels installed for producing electricity?
	Q42	If it saves me a few tens of euros per year, I am prepared to slightly adjust my behavior in order to make more efficient use of sustainably produced electricity (e.g. by not using the washing machine during peak hours)
	Q43	I am interested in installing a smart energy management system in my household, which can automatically reduce energy use or switch off appliances during peak hours.
Local renewable energy sources	Q22	What is your house's energy label?
	Q24	Do you produce electricity (are you a prosumer)?
	Q34	If you answered No / No, but I would like to: What is keeping you from getting solar panels installed on your house?
	Q38	I view myself capable of realizing more energy savings (compared to now).
	Q39	I am willing to invest in renewable energy
	Q60	The community where I live should be able to share and store energy within our community and rely on the national energy system as little as possible.
Settlement characteristics	Q6	How would you describe your political views?
	Q7	What type of house do you live in?
	Q12	How are energy matters discussed with your neighbors? Choose all that apply.

	Q13	How would you characterize the natural environment around in your neighborhood?
	Q18	Do you own or rent your house/apartment?
	Q19	How many people are residing in your house/apartment (your apartment unit, not the whole building)?
	Q53	Generating one's own energy locally is an important value in my social circle/network.
Building characteristics	Q15	How large is your house in square meters? (Excluding outdoor space such as gardens, balconies etc.)
	Q16	When was your home built?
	Q17	When was your home renovated?
Complexity of energy uses	Q4	What is your gender?
	Q14	What is your gross household income (before tax)?
	Q20	How many of those people are minors (Aged 17 or less)?
	Q21	What is the gender division of the household members?
	Q25	What is the primary source of house heating in your house? Choose all that apply.
	Q26	How much electricity does your household use per year? (in kWh)
	Q27	How much money do you spend on heating per year?
	Q33	If you said yes to owning solar panels, what is the system size of your solar panels? (in kWp)
	Q36	If you said yes to the two previous questions, was it difficult to interact with authorities to issue a permit and have them installed?
Socio-regulatory dimensions		
Scope of autarky	Q49	It is best if initiatives come from local communities themselves.
	Q59	I feel sufficiently well-informed to participate in decision-making for the energy system in my community (e.g. related to infrastructure development, network operation and energy trading)
	Q61	In principle, 100% of the energy local demand in my community should be covered with local renewable energy.

	Q62	My settlement should be self-sufficient in supplying residents' energy as well as recovering/recycling/disposing of our own waste/emissions.
	Q63	We should have a high degree of freedom to experiment and implement local energy solutions independently of national regulations in our community.
	Q64	I prefer a high level of local community autonomy, to govern our local (energy) affairs on our own initiative.
Alignment of energy values	Q41	Without any financial compensation, I am prepared to slightly adjust my behavior in order to make more efficient use of sustainably produced electricity, for example by not using the washing machine during peak hours.
	Q44	If you answered No or I don't know to the previous question, what are the main concerns that keep you from wanting to use such a smart energy system?
	Q45	Production of renewable energy is important.
	Q46	Lower energy price is more important to me than sustainable energy.
	Q47	I support the construction of new renewable energy projects (such as solar farms, wind turbines) in my community.
	Q51	National government policy mainly supports:
	Q52	Saving energy (energy efficiency) is an important value in my social circle/network.
	Q54	The climate changes in my immediate surroundings (i.e., my home or my neighborhood) is an important factor for me in making energy related decisions.
Formal self-governance	Q37	I would like to lower my energy consumption.
	Q48	Global climate change is important.
	Q56	I like to participate in a common project together with the neighborhood to save or produce energy.
Energy and land regulations	Q28	How much do you pay for electricity per year?
	Q35	Do you have one of the following devices installed? Check all that they apply
	Q40	How much more are you willing to pay extra if your energy is renewable energy?
	Q50	I would like my energy producer to be more locally controlled (e.g., communities, municipalities)

Social organization	Q8	How would you characterize the area where you currently live?
	Q9	Are you a member of a local association? Are you active in your community?
	Q10	What kind of local associations themes are you active in? Choose all that apply.
	Q11	How are energy matters discussed with your neighbours? Choose all that apply.
	Q55	I feel better if the energy system becomes more sustainable.
	Q57	Decisions on the local energy system, such as energy sources and supply structures, should primarily be taken by: (select all that apply)
	Q58	I feel sufficiently well-informed to take decisions about my own energy supply.
Background	Q2	Are you an inhabitant of?
	Q3	What is your age?
	Q5	Are you currently living in the region that you were born in?