D4.1

Characteristics of energy communities and motivations, engagement, and socio-economic profiles of end users

SUMMARY

This report provides a literature review on characteristics and organizational models of energy communities, motivations, engagement, and the socio-economic profile of end users. The result is a description of energy communities for GENTE.

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Abstract

The ERANET GENTE project aims to develop a distributed governance toolbox for local energy communities (LECs) or more generally energy communities (ECs). This toolbox includes advanced digital technologies such as the internet of things (IoT), distributed ledger technology (DLT), edge processing and artificial intelligence (AI) for autonomous energy resource management within and across LECs and for flexibility provisions to energy networks. The toolbox also considers social processes and includes a set of guidelines and methods for developing new LECs with potential end users and further stakeholders.

This report provides a literature review on definitions and characteristics of energy communities including organizational models, motivations, engagement and the socio-economic profile of end users. The report begins by exploring the meaning of "community" within the context of energy communities and examines existing typologies and analytic dimensions found in the literature. It then discusses the diverse organizational models adopted by energy communities. Motivations for user engagement and participation in energy communities are examined, along with an analysis of end users' demographic and socio-economic profiles. A case study of the residential estate "am Aawasser" provides a practical illustration of the concepts and dimensions discussed. Finally, the report proposes a simplified and practical description framework for energy communities for GENTE.

The main results of the report include a definition of energy communities, and a set of dimensions for describing energy communities. For the purposes of GENTE, the relevant meanings of “community” are identified as community by technology, community of place and community of interest. The ECs GENTE targets and wants to promote will generally fit simultaneously in all three categories.

The report also lays down mandatory characteristics which an energy community within the scope of GENTE will fulfil. For GENTE, an energy community which fulfils these characteristics is an energy project (1) involving energy consumers and/or prosumers who share renewable energy generation units, (2) who live in a shared place or have a shared interest and (3) have some level of control over or participation in the project. We assume energy communities will also be connected to the public grid, organized as a legal entity and have only “smaller actors” as members.

The report also defines 4 archetypes (and 4 four sub-variants) in Section 6.2. These are intended to provide an illustrative set of types of energy community to facilitate discussion within the project and help align technology development. The main archetypes are (1) *Community-led local optimization communities*, focused on local optimization and with a single connection to the grid (2) *Virtual community-led local optimization communities*, with a virtual connection type, (3) *Business-led service-focused communities*, with a single connection to the grid and (4) *Virtual business-led service-focused communities*.

The report further summarizes insights on organisational models adopted by energy communities, end user engagement and roles, motivations of end users and their socio-economic profiles.

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List of Abbreviations

CEC	Citizen Energy Communities
EC	Energy Community
ERA-Net SES	ERA-Net Smart Energy Systems
FIP	Feed-in premium
FiT	Feed-in tariff
GENTE	Distributed Governance for green ENergy communiTiEs
LEC	Local Energy Community
REC	Renewable Energy Community

1. Introduction

The ERANET GENTE project aims to develop a distributed governance toolbox for local energy communities (LECs). This toolbox includes advanced digital technologies such as the internet of things (IoT), distributed ledger technology (DLT), edge processing and artificial intelligence (AI) for autonomous energy resource management within and across LECs and for flexibility provisions to energy networks. The toolbox also considers social processes and includes a set of guidelines and methods for developing new LECs with potential end users and further stakeholders.

The solutions developed within GENTE for the governance of LECs will be validated first at the lab levels, and then at real full-scale environments in order to increase technology readiness levels (TRL) of solutions. GENTE project will be tested in several pilots with diverse characteristics. This variety of pilots, from living labs to real environments, provides a good representation of LECs. In total, GENTE has 6 demonstrators at different scales in Sweden, Switzerland, and Turkey which can demonstrate solutions for new types of technologies and services in different technical, environmental and market contexts.

This report provides a literature review about definitions and characteristics of energy communities including organizational models as well as motivations, engagement, and socio-economic profiles of end users. The result is a description of LECs for GENTE. In this report, we generally use the more open term "energy communities" (ECs) rather than LECs.

This report is structured as follows: Chapter 2, introduces the topic by first exploring the meaning of "community" within the context of energy communities. It then examines existing typologies and analytic dimensions found in the literature. Chapter 3 discusses classical and contemporary attempts to categorize the diverse organizational models adopted by energy communities, as these models play a critical role in shaping the structure and operation of such communities. In Chapter 4, the motivations behind various forms of user engagement are examined, as well as the demographic and socio-economic profiles of end users in energy communities. Chapter 5 presents a case study of the residential estate "Am Aawasser" to provide a practical illustration of the discussed concepts and dimensions. Finally, Chapter 6 reduces the complexity within the research literature and provides a useful description framework for energy communities within GENTE. The framework includes mandatory and optional characteristics that will facilitate the analysis and description of these communities and the following co-design process. Additionally, four *archetypes* are proposed, i.e. brief characterizations of ECs with combinations of characteristics which are particularly relevant to GENTE.

2. Definitions & Characteristics of Energy Communities

This chapter discusses the meanings of the term *energy community*. After the introduction (2.1), we summarize the debate on what the term *community* means in the energy context (2.2). Then we provide an overview over the large variability of definitions and typologies of energy communities. We do this by discussing a selection of papers from the literature on energy communities and the analytic dimensions they propose (2.3). Section 2.4 offers a synoptic overview of the dimensions gathered from the literature. Finally, Section 2.5 examines the definitions of energy communities in EU legislation.

2.1. Introduction

As a point of departure for our discussion of the meaning of the term energy community in the current literature and across Europe we choose the following definition. “Energy communities involve groups of citizens, social entrepreneurs, public authorities and community organizations who participate directly in the energy transition by jointly investing in, producing, selling and distributing renewable energy” (Interreg Europe, 2023)

The definition captures much of what is generally understood to be an energy community. However, as one delves deeper into definitions and typologies of energy communities, a range of questions emerge. Must energy communities always involve citizens, or does a combination of other stakeholders suffice? Can for-profit organizations be part of energy communities and if so in what role? To what extent must citizens be involved in an energy community to justify speaking of an energy community? Who counts as a “citizen”? If members of an energy community “jointly” invest in or produce energy, what does this imply for decision making within the community or for the distribution of financial benefits to members?

The concept energy community has been the topic of many journal articles and research projects over the last years. While the term has appeared in articles since the 1980s, the number of articles discussing energy communities has increased by a factor of 20 since the beginning of the 2000s ((Bauwens et al., 2022, p. 7). The introduction of two legal definitions relating to energy communities – Citizen Energy Communities and Renewable Energy Communities – in EU law in 2018 and 2019 (Schmid, 2021) is further evidence of the growing relevance of the concept and the phenomenon beyond the research context (and is discussed in Section 2.5).

Many authors reflecting on the energy community concept in the recent research literature conclude that the term is used in many different ways, with no broadly accepted definition of what comprises an energy community (e.g. Bauwens et al., 2022; Kubli & Puranik, 2023; van Veelen, 2017; Verde et al., 2020). As van Veelen argues, trying to offer a universal definition for energy communities makes little sense and would obscure the great variability of the real-world phenomena which are referred to by the term (van Veelen, 2017, p. 3–4). In this report we will not aim at such a “universal” definition. Rather, we will discuss and identify central dimensions of energy communities drawing on a selection of the research literature and use these to provide a working definition and a set of archetypes for the GENTE project in Chapter 6.

2.2. The meaning of *community* in energy communities

One central debate in the literature turns on the question of what “community” means in the energy context (Walker et al., 2008). This discussion relates also to the equally broad concept of “community energy”, and the many more specific terms which have developed within this field, such as “energy cooperatives” (Schmid et al., 2020), “prosumer communities” (Espe et al., 2018), “grassroots energy initiatives”, “community energy enterprises”, “citizen energy projects” and others (Walker et al., 2022).

As Walker et al. note, no matter what it is intended to mean, the term community within the context of energy communities is always “constructed and political” and is often used to promote a certain set of interests (2022, p. 3). Community is a “warmly persuasive word” (Williams cit. in Walker et al., 2022, p. 777), which suggests many positive things, with energy community often connected to social cohesion, empowerment of citizens, sufficiency, sustainable energy behaviors, acceptance of technologies or the economic revival of local communities (Bielig et al., 2022). Additionally, community often remains vague as to what constitutes membership within a community and what the boundaries of community are.

Discussions of the meaning of community in the context of energy communities and energy projects identify several distinct (though potentially overlapping) meanings of community. In the following we discuss community as (1) technology, as (2) place, as (3) network, interest or identity, as (4) actor and as (5) scale (Bauwens et al., 2022, Walker et al., 2022).

In the GENTE context particularly, an important distinction to make is between technology-related concepts of community and social/organizational concepts. Community constituted by technology is a concept utilized in the engineering sciences and refers to shared use of energy resources (Bauwens et al., 2022, p. 3). One such definition states an energy community is “a group of consumers and/or prosumers, that together share energy generation units and electricity storage” (Schram et al., 2019, p. 2). The members of such a community are materially connected by technological structures (Bauwens, 2022, p. 4), such as microgrids or smart grids. At least implicitly, the “community by technology” concept also includes a scale criterion, as an energy community is separate from the public grid, though often connected to it (e.g. Schram et al., 2019, p. 2).

In much of the energy-related social-science literature, the focus of the debate has been on which social, not technological, criteria constitute an energy project as a community energy project (Bauwens, 2022). “Community of place” is probably the meaning most commonly associated with community in regard to energy projects (Bauwens et al., 2022, p. 8, see also Walker et al., 2022, Walker, 2011). Usually, “community” here refers to a pre-existing territorial entity with defined borders, i.e. an administrative district, village or neighborhood, within which or near to which the technical energy structures are located. The inhabitants or citizens of this entity are generally the ones who may participate in, benefit from and/or be affected by the energy project. One could also imagine that an energy community is established as a newly formed "community of place" by coalescing neighboring households to a new entity.

In opposition to "community of place", the concept of "community as network" or similarly "community of interest" and "community of identity" (Walker et al., 2022) is applicable to energy communities which are not geographically bounded, but rather consist of members who may be geographically dispersed (Walker, 2011, p. 778), but share common aims, interests and possibly values. An example would be a nationally active energy cooperative which installs PV in suitable locations and is open to members all over a given country.

A further common meaning of community in the energy context is the "community as actor" (Bauwens et al. 2022, p. 8, Walker 2011, p. 778). Here the community is a specific collective entity which can take action, e.g. a cooperative or a local public authority. While this can overlap with "community of place", community in this sense refers to a precisely defined organizational entity (a cooperative, a company) which can take action, be addressed, interact with others etc. as opposed to all the citizens of e.g. a village.

Finally, the meaning ascribed to community in energy projects often relates to "scale" (Bauwens et al. 2022, p. 8, Walker 2011, p. 778), where community is a term which is located "within a hierarchy of interacting scales of action" (Walker 2011, p. 778). Community here indicates that a project is at a level above the individual or the household, but below the level of local government.

Based on the technologies GENTE is utilizing and developing, an energy community relevant to GENTE will need to fulfill a "community as technology" criteria. This implies that members of the community, certainly all end-users, in a broad sense "share" energy generation assets or other energy infrastructure. However, while this is a necessary criterion, we would not see it as sufficient to classify an energy project as an energy community within GENTE. From a GENTE perspective, energy communities probably also need to be "communities of interest" and "communities of place", with members sharing some level of common aims or values and personal contacts (Walker et al., 2022). Without this dimension of community, members connected by technology remain anonymous prosumers or consumers, with no particular motivation for joining or contributing to an energy community.

2.3. Typologies and analytic dimensions in the literature

In this section, we discuss nine papers which deal with community energy and energy communities and present typologies of communities and substantial sets of dimensions for describing energy communities. We include papers on both community energy and energy communities, as there is no clear distinction between the concepts.

The papers were selected on the basis of offering an explicit and substantial discussion of analytic dimensions for describing energy communities. We begin with the 2008 paper by Walker and Devine-Wright which is one of the most frequently cited papers in the field (489 citations in Web of Science, 6.6.2023). Van Veelen (2017) and Sebi and Vernay (2020) each offer a typology with dimensions similar to those of Walker and Devine-Wright based on data from two European countries, while Hicks and Ison (2018) provide another informative set of dimensions based on the Australian context. The three following papers each develop analytic dimensions from a specific, more unconventional conceptual perspective. Kubli and Puranik (2023) propose a set of dimensions very similar to those of the previous authors but from a business model perspective. Gui and MacGill (2018) employ a social network perspective, while Becker and Kunze (2014) place political aspiration at the center of their discussion. Finally, we discuss two papers which deal with an essential technological dimension, connection type. In our analysis, we work towards the summary provided in Table 2, where we provide an overview of the dimensions proposed by the papers.

While informed by various theoretical frameworks, the work on typologies and conceptualization of energy communities inevitably refers explicitly or implicitly to empirical cases in specific countries. These national contexts are important, as the differences in regulatory context, market structure, civil-society traditions, geo-physical characteristics etc. shape the emergence of energy communities. This means that the types identified by different authors are not necessarily transferable to other contexts. The types diverge in certain aspects but also display similarities which are informative for the contexts we are interested in within GENTE. However, the focus in this report is less on the types and typologies, and more on the dimensions employed to construct them. These are more easily transferred and are the focus of the following discussion.

2.3.1. Two fundamental dimensions: participation and benefits

An influential conceptual framework is provided by Walker and Devine-Wright (2008) who discuss the meaning of “community renewables” in the English context. Fundamentally they ask “Who is the project by?” and “Who is the project for?” (Walker & Devine-Wright, 2008, p. 497). Their framework orders energy projects along two dimensions: one is the degree of participation of the local community (or “process” in the authors’ terms), the other the degree to which benefits flow to the local community (what the authors label “outcome”). The participation dimension relates to who is involved in the development and running of a project, and ranges from open and participatory to closed and institutional. In a project situated on the “institutional” extreme, decisions would typically be made by companies or authorities, i.e. by experts acting in a professional function. This is contrasted with participatory processes where citizens are involved in decision-making processes.

The benefit dimension refers to who receives benefits – primarily financial benefits – from a project and ranges from local and collective to distant and private. It thus measures how benefits are “socially and spatially distributed” (Walker & Devine-Wright, 2008, p. 498). A “distant” destination for benefits can be imagined as profits going to a company and its shareholders situated far from the site of the energy project in a national capital or a foreign country.

The authors do not develop a typology of community energy projects, but they do argue that the label community energy should be limited to projects with high levels of participation of local communities and a substantive degree of benefits flowing to the local community. The two dimensions identified in this paper are undoubtedly fundamental and appear in most typologies which have come since. As Walker and Devine-Wright note, the dimensions do not refer to technology but to the "social arrangements" (Walker & Devine-Wright, 2008, p. 498) of the energy project.

2.3.2. Adding technical and social dimensions

Based on research on the Scottish energy landscape, van Veelen (2017) develops a typology of community energy which considers technical and social dimensions of 367 energy projects. Van Veelen only includes projects which (1) generate energy, (2) are "community-driven" (2017, p. 5) in the sense that they include "some form of active community participation" (2017, p. 5), (3) have some level of benefit flowing into the community (2017, p. 3) and (4) where the "community" is defined by place, interest or identity. The previously discussed dimensions of participation and benefits are thus important for the focus of this typology, which, however, goes beyond Walker and Devine-Wright's dimensions.

Van Veelen posits a typology built on eight dimensions: technology, size of installation, type of legal entity, type of organization, other assets owned by community, ownership model, link between energy generation and use, and primary motivation. The dimensions and the options on them are summarized in Table 1.

Table 1 - Descriptive dimensions in Van Veelen (2017)

Dimension	Positions
Technology	Photovoltaics - heat pumps - wind - hydro - tidal - smart grid and storage
Size of installation	Micro (<15kW) - small – medium – large (>1000kW)
Legal entity	Unincorporated association - trust - company with/without charitable status - cooperative
Type of organization/community	Local group or association (e.g. community hall, sports club) - local development organization - energy cooperative - transition town
Other assets owned	Buildings - land – none
Ownership model of energy assets	Full community ownership - joint venture
Link energy generation – use	Self-consumption - sale to grid
Primary motivation for energy community	Increase comfort (of buildings) – lower energy costs – generate local income – increase self-sufficiency – reduce carbon footprint – gain control of project planned

Using these features, Van Veelen develops a typology with six distinct types of community energy project for the Scottish energy landscape. She names them “small but beautiful”, “community developers with ownership”, “community developers without ownership”“energy cooperatives”, “innovators” and finally “transition towns” (2017).

“Small but beautiful” energy communities are small projects run by local associations or trusts with a focus on local activities and welfare which generate energy for self-consumption, typically for a building used by the group, with the aim of lowering energy bills and/or increasing comfort. Financial revenues are not an objective. “Community developers” on the other hand generate energy to generate income. They are typically medium-sized projects run by companies or trusts which sell energy to the grid and use revenue to benefit the local (place-based) community, e.g. by providing employment or housing. They may or may not own the assets. “Energy Cooperatives” do not own the assets but invest mostly in large renewable projects which sell all electricity generated to the grid. They are often but not necessarily run by local members. They represent a kind of shareholding cooperative, with the aim of either increasing investments in renewables for environmental reasons or of gaining some control over energy projects planned by other, non-local actors. The type “innovators” is characterized mainly by the fact that these energy communities try to implement innovative technological solutions, often due to constraints and in the context of self-sufficiency of small islands. Finally, the rather marginal “transition towns” are broader initiatives within which energy is one of several interests and which often do not fulfill the criterion of generating energy themselves.

While community participation and types of organizational control are defining features for this paper, the typology does not aim to distinguish different forms or levels of participation, and forms of ownership also remain somewhat vague. Other scholars choose to be more explicit on this topic, such as Hicks and Ison (2018) and Sebi and Vernay (2020), which are discussed in the next sections.

2.3.3. Towards simpler, more abstract dimensions

In their discussion of “community renewable energy”, Hicks and Ison (2018) present a simpler, more abstract set of characterizing dimensions than Van Veelen, while many parallels remain. They identify five core dimensions of energy communities: range of actors involved, distribution of voting rights and decision-making power, distribution of financial benefits, scale of the technology, and the level of community engagement (cf. Verde et al., 2020). They focus on the dimensions without developing a typology.

The authors describe five options on each dimension. The “actors” dimension runs from “only local individuals” on the one extreme to “only non-local organizations, business and government” on the other (Hicks & Ison, 2018, p. 529). In between lie “local individuals, business and government”, “mix of all actor types, more local than non-local” and “mix of all actor types, more non-local than local” (Hicks & Ison, 2018, p. 529). Thus, actors are distinguished according to whether they are individual or collective, and whether they are local or not. The closest dimension to this in Van Veelen’s typology is the “type of organization”, but with the non-local actors Hicks and Ison cover an area Van Veelen does not.

As mentioned above, “decision making” is characterized more explicitly than by Van Veelen. This dimension extends from “one member one vote” to “one actor has all votes” (Hicks & Ison, 2018, p. 529).

The degree to which control is concentrated and the principle on which voting rights are allocated (membership or proportion of shares) are the issues here. Questions of ownership are subsumed into this dimension. The "financial benefits" dimension starts at one end with benefits flowing into a "community fund" (Hicks & Ison, 2018, p. 530). The other options on the dimension involve benefits increasingly flowing to investors and increasingly to non-local as opposed to local actors. An issue in the "scale of technology" dimension is whether the technological installation is dimensioned to serve local demand or to maximize economies of scale, and to what extent local interests and resistance (e.g. in relation to effects on the landscape, typically in the context of wind energy) are taken into account.

The final dimension, "community engagement" is an attempt to capture how much the community – whether this is a place-based community, an interest-based community or other – is involved in decisions around development and running of an energy project. One aspect is how early on in the project engagement starts, another is how frequent engagement is. Many of Hicks and Ison's dimensions display a spectrum between a local, common-good orientation and a for-profit and market orientation.

2.3.4. Control and revenues in focus

In their paper on community energy in France, Sebi and Vernay consider what they call "community renewable energy projects" (2020). In a similar vein to Van Veelen, they limit the scope of their research to energy projects which involve a certain level of community participation. However, they define this more precisely as the presence of some degree of participatory investment combined with some access to project governance by citizens (Sebi & Vernay, 2020, p. 4). Regarding technological issues, the communities considered here are all involved in the generation of energy (as in van Veelen 2017). Most of the projects on which the paper is based are focused on rooftop PV, a considerable number on wind power, and a few on small-scale hydro, biogas and biomass projects (Sebi & Vernay, 2020, p. 4). Given the restrictions of the French context, self-consumption (direct use) of energy generated seems to have been virtually non-existent and is thus not a characteristic of the energy projects discussed (Sebi & Vernay, 2020, p. 4).

The authors develop their typology using two central dimensions: the revenue model and the governance structure. Each dimension has two options. The revenue model is either feed-in tariff (FiT) or feed-in premium (FiP), which is in effect a size dimension, as projects below a certain capacity are eligible for FiT, while larger ones can only receive FiP. Regarding governance structure, the typology distinguishes between voting rights based on an equality principle (one member one vote) or voting rights proportional to shareholdings.

Four types result from this two-by-two structure. "Citizen PV clusters" (FiT and equality principle) are typically small, mostly rural projects with rooftop PV and a low or non-existent return on investment. They are mostly volunteer run with an active membership consisting of local citizens and public bodies, with between 40 to 500 members. This type is similar in some ways to Van Veelen's "small but beautiful" projects, but they differ from them as the energy is not directly consumed and thus environmental objectives are in the forefront. "Never too big for citizens" (FiP and equality governance projects) are larger energy projects, mostly wind, and achieve a higher rate of return on investment. Local authorities play a key role in establishing these more complex projects. They have between 200 and 800 members. The so-called “neither demagogue nor angel” type (FiT and proportional governance) are smaller projects which are focused on profitability. They are often initiated by businesses or local public actors and are positioned in (technological) niches which can provide the profitability demanded. Finally, the category “co-developed with private/public actors” (FiP and proportional governance) are large projects like wood-chip district heating or wind farms, initiated by energy companies or public-private partnerships, but again open to citizen investment and (minority) citizen control.

While the authors use only two dimensions to set up their typology, they employ additional criteria when describing the characteristics of the types they identify, drawing on the empirical examples. Such additional dimensions are the motivation for the establishment in the community (as in Van Veelen’s typology), the intensity of citizen participation (similar to Hicks and Ison’s community engagement), the number of members and the actors involved. This final dimension refers to the role of volunteer activists, of public authorities and (energy) businesses in establishing and running the energy community. This echoes Walker and Devine-Wright’s distinction between participatory and institutional approaches to setting-up and running an energy community. Sebi and Vernay, however, give more emphasis to the notion that different combinations of citizen and institutional involvement in projects may exist, rather than viewing them primarily as opposing extremes.

2.3.5. A business model perspective

Kubli and Puranik (2023) enter the debate with a business model perspective and develop a set of descriptors for energy communities. They identify five dimensions, many of which capture - despite the business model perspective - broad characteristics of energy communities which are also relevant from other perspectives.

The dimensions they propose are “community value proposition”, “energy community members”, “energy value capture”, “key functions” and “network effects”. The community value proposition is largely analogous to the “motivation” dimension suggested by Van Veelen (2017) or Sebi and Vernay (2019). It includes “generating renewable energy”, “increasing self-consumption”, “increasing grid reliability”, “reducing energy consumption”, “reducing energy costs” and “becoming a living lab”. Increasing grid reliability as a central value proposition is primarily relevant to areas where electricity outages occur. It can also be forward looking, in a sense of avoiding grid expansions and future instability.

The “members” dimension is similar to Sebi and Vernay or Hicks and Ison, but is more specific and contextualized, mentioning “residential prosumers”, “large-scale prosumers”, the “local energy producer”, “energy service companies” and “community platform operators”. “Energy value capture” overlaps somewhat with the authors’ value proposition dimension and other “motivation” dimensions, but has a justification as it provides more precision on what makes an energy community economically viable. Apart from “saving energy costs” and “revenues from energy services (for members)”, which are mentioned in other dimensions, this dimension includes the options “revenue from external services”, “community service fee” and “data valorization”. These latter options are rarely found in existing energy communities so far but point to possible business models.

The “key functions” dimension focuses on the activities of the energy community and encompasses “facilitating P2P trading”, “aggregating energy and flexibility”, “managing storage systems”, “co-optimizing energies” and “coordinating (external) partners”. Co-optimizing energies refers to optimizing the fit of demand and generation profiles and is a means of increasing self-consumption within an energy community.

Finally, Kubli and Puranik consider network effects, though in a different way than Gui and MacGill (2018, see below). They group a number of rather different characteristics into this dimension with the options “peer and community effects”, “economies of scale and scope”, “learning effects” and “co-benefits and co-amortization of investments”. Peer and community effects refer mainly to the strength of a feeling of community inspiring people to join and stay in a community. Seeking economies of scale and scope is a strategy for energy communities to e.g. reach a minimum size necessary for offering external services or reduce costs by growing. Learning effects can result on different levels – institutional, technological – and can lead to lower costs and higher quality. Co-benefits are synergies between complementary goods or assets, such as PV generation and electric vehicles, which allow both to be used more efficiently.

2.3.6. Social networks as an alternative structuring principle

Gui and MacGill (2018) discuss what they term “Clean Energy Communities”, mainly in the Australian context. The novelty of their approach is that they base their typology on a social network perspective (Gui & MacGill, 2018, p. 95), with the density and structure of the network as the main criteria. They propose three basic types of energy community, “centralized”, “distributed” and “de-centralized”. The dimensions they use to describe the types are governance and control, ownership, and social cohesion.

“Centralized” does not refer to geographic centralization, but rather to a dense social network, which the authors conceptualize with aspects of governance and social cohesion (Gui & MacGill, 2018, p. 100). Regarding governance, this implies a clearly defined executive body which represents and acts in the name of members, while all members have equal voting rights (equality principle), and the opportunity to enter executive positions. Regarding social cohesion, a centralized energy community is characterized by personal contact between members and shared goals and values. A centralized energy community does not produce energy for self-consumption, its members are not connected in any way by the technology (Gui & MacGill, 2018, p. 100-101). A comparison with Sebi and Vernay (2020) highlights the alternative approach of Gui and MacGill, as all of Sebi and Vernay’s types would be likely to fall under this one type.

“Distributed” refers to a non-dense network, typically models such as VPP and P2P platforms (Gui & MacGill, 2018, p. 101). Social cohesion is low here, members neither know each other nor is it necessary they share values. Members’ decision to join is mainly driven by perceived individual benefits. The network is managed by a provider of a hub or platform, usually a firm, which acts either as a “broker” for communication and financial transactions or in distributed energy communities with more active involvement of members, as an “enabler”. The energy community is governed by common rules on how energy is shared or traded, but members do not necessarily have any control over these rules.

Collective ownership is generally not involved, rather the energy community connects individually owned energy assets (Gui & MacGill, 2018, p. 101-102).

The type "decentralized" is typically a small community of co-located buildings with generation assets and self-consumption. On network terms, this type is very similar to the centralized energy community: it is a dense social network, members are in direct contact and share common goals, values and rules. The differences are that decentralized energy communities are geographically bounded (small municipalities or just neighboring buildings), members are often prosumers and the aim is some level of self-consumption. In the case of off-grid examples, these energy communities are microgrids with full energy autonomy and 100% self-consumption rates (Gui & MacGill, 2018, p. 102-103).

While the types which Gui and MacGill develop disregard some distinctions which are important in other typologies, the social-network perspective they introduce highlights characteristics of energy communities which many others miss.

2.3.7. Political objectives as a necessary feature?

Many discussions of energy communities portray them as part of a major change in the energy landscape and connect them to energy justice or energy citizenship. Some authors, however, give particular emphasis to this feature, including Seyfang (2013) who defines energy communities as "civil society action around sustainable energy". Becker and Kunze (2014) go a step further in their discussion of innovative renewable energy initiatives in Europe. They deem the "community" label to be overly restrictive and poorly suited as a central descriptor of such projects. They prefer to use the term "collective and politically motivated renewable energy (CPE) projects" (Becker & Kunze, 2014, p. 182) to identify what is generally referred to as "community energy". Their definition employs two core dimensions: "collective ownership and political aspiration". Collective ownership relates to the dimensions of participation and control which other typologies employ. The authors opt for ownership as it represents a more stable legal base for control than other forms of governance. Beyond that, ownership implies the more symbolic, psychological and affective dimensions of entitlement and appropriation. The idea of community is preserved with the dimension of collective ownership but becomes more flexible to different contexts and models. Political aspiration on the other hand refers to the project having the objective to contest existing political orders and bring about change (e.g. in the power structure of the energy market). According to Becker and Kunze, it is a necessary characteristic to qualify energy projects that can open up new futures regarding energy. While we do not regard a political aspiration as a precondition for an energy community, it is worth considering this as a dimension of energy communities, especially if the aims associated with energy community promotion include issues of energy justice or energy citizenship.

2.3.8. Connection type

One technological and regulatory characteristic of energy communities, the dimension considering the form of connection of the energy community to the grid, is essential in the GENTE context due to energy distribution and control considerations.

(Cielo et al., 2021; di Silvestre et al., 2021). Two basic types of connection to the grid and between community members are relevant for our purposes: single connection to the grid and a distributed, virtual connection (di Silvestre et al., 2021, p. 7-8). A single connection to the grid (what di Silvestre et al. call the "physical model" [2021, p. 7]) uses a single point of connection to the grid, behind which all members/buildings of the energy community are situated. The energy community has its own distribution network which connects end users (di Silvestre et al., 2021). Self-consumption within the community can be measured at the meter just upstream of the point of connection to the grid. One way of defining self-consumption is the minimum between energy introduced into the grid and energy consumed from the grid, measured in regular time periods, e.g. hourly (Cielo et al., 2021, p. 3; di Silvestre et al., 2021, p. 8). The virtual connection type is when each end user within the energy community (e.g. each building) has their own point of connection to the grid (di Silvestre et al., 2021, p. 8; under Italian legislation all end users with this virtual connection must be located within the same low-voltage section of the public grid). Self-consumption is measured as in the physical model, but by taking the minimum of the summed introduced and consumed energy across all meters.

2.4. Overview of analytic dimensions

Table 2 summarizes the discussion above by collating the analytic dimensions drawn from the nine papers. The table is loosely grouped by topics, beginning with dimensions relating to technical issues, then to people and finally to organizational issues. In some cases, we group similar dimensions from different papers, using our own label for the dimension or one from the respective papers. In some of these cases we also summarize similar options on dimensions, in other cases we list options from different papers separately.

Table 2 - Overview of energy community dimensions

	Dimension	Options	Source
1	Type of technology	PV / wind / biogas / biomass / wood-chip heating / heat pumps	Sebi & Vernay, Van Veelen
2	Scale of technology	Scaled to maximize consideration of local community interests / [various intermediate options] / scaled to maximize economies of scale and profits	Hicks & Ison
3	Size / Generation capacity	Micro (<15kW) / small (15-100kW) / medium (100kW-1MW) / large (> 1MW)	Sebi & Vernay, Van Veelen
4	Link between generation and use	Self-consumption / sell to grid	Van Veelen
5	Connection type	Single connection to the grid / virtual connection	Di Silvestre et al.

6	Key functions	Facilitating P2P trading / aggregating energy and flexibility / managing storage systems / co-optimizing energies / coordinating (external) partners	Kubli & Puranik
7	Actors involved	Public actors / companies / individuals Only non-local authorities and businesses/ [various intermediate options] / only local individuals Residential prosumers / large-scale prosumers / local energy producer / energy service company / community platform operator	Sebi & Vernay Hicks & Ison Kubli & Puranik
8	Number of members	[quantitative dimension, not further specified]	Sebi & Vernay
9	Distribution of benefits	Local + collective / [various intermediate options] /distant + private	Walker & Devine-Wright, Hicks & Ison
10	Primary purpose / motivation	Benefits to local group / economically developing local community / promoting renewables / gaining control in large projects / increasing self-consumption / increasing grid reliability / reducing energy consumption / reducing energy costs / becoming a living lab	Van Veelen, Sebi & Vernay, Kubli & Puranik
11	Revenue objective, energy value capture	No financial benefit / lowering energy costs / generating revenue from selling energy / revenue from external services / community service fee / data valorization	Sebi & Vernay, Van Veelen, Kubli & Puranik
12	Voting rights / control	Equality principle / proportional to investment with limitations / proportional to investment without limitations	Sebi & Vernay, Hicks & Ison, Becker & Kunze
13	Degree / intensity of community participation	Open + participatory / closed + institutional Starts late, occurs rarely and via very limited means / (different intermediate options) / starts early and occurs often, using a broad range of methods	Walker & Devine-Wright, Sebi & Vernay Hicks & Ison
14	Density of network structure	Dense / sparse	Gui & MacGill

15	Network effects	Peer and community effects / economies of scale and scope / learning effects / co-benefits and co-amortization of investments	Kubli & Puranik
16	Ownership of energy assets	Full community ownership / joint venture	Van Veelen
17	Political aspiration	Low / high	Becker & Kunze
18	Legal entity	Unincorporated association / trust / company with/without charitable status / cooperative	Van Veelen
19	Principle of community	Place-based / interest-based	Van Veelen
20	Social cohesion	Shared values and goals + frequent face-to-face contacts between members / [various intermediate options] /only shared goals + no face-to-face contacts	Gui & MacGill
21	Geographic scope	Local / non-local	Hicks & Ison

2.5. Energy communities in EU legislation

Apart from the research literature, it is informative to look at the relevant legislation on energy communities. In this section we summarize the EU legislation on energy communities, which is of central importance given the European focus of GENTE. As a legal term, energy community has entered EU law only very recently, in two pieces of legislation in 2018 and 2019 (see below). Two legally defined forms of energy communities currently exist in the EU: “citizen energy communities” (CECs) and “renewable energy communities” (RECs). In both cases, the purpose of the legislation is to facilitate market access of each type of energy community.

The two forms of energy community are distinct, but share the following characteristics:

- They produce, consume, store and/or sell energy.
- They can share energy they produce themselves within the community.
- They must be organized as a legal entity (e.g. association, cooperative, partnership, non-profit organization, small/medium enterprise [SME]).
- Participation must be open and voluntary, i.e. access (and exit) must be non-discriminatory.
- Members may be individuals, public bodies or small enterprises.
- The energy community must be effectively controlled by its members.

- They have a non-profit focus: providing environmental, economic and/or social benefits to members and/or the area where the energy community operates must have priority over making financial profit.

The differences are as follows:

- CECs can conduct more activities related to energy distribution.
- The effective control over a CEC must be limited to individuals, public bodies and small enterprises. In RECs, *medium-sized* enterprises may also have a share in control of the community.
- RECs are local, in that shareholders or members must be located in the proximity of the renewable energy projects that are owned and developed, while for CECs there is no such geographic restriction.
- RECs produce different energy forms (electricity, heat) but only from renewable sources while CECs only engage in activities related to provision of electricity, but regardless of whether the source is renewable.
- RECs are granted a number of privileges with the aim of promoting them, e.g. simplified regulation, access to funding and information and special treatment in subsidy schemes.

The EU emphasizes the following benefits of energy communities: a) for energy transition: increasing the acceptance of renewable energy projects, attracting more investment, partly local, into renewables and offering flexibility to the grid through (aggregated) services; b) for citizens: lowering energy costs and creating local jobs (Schmid, 2021).

The core ideas mentioned in the two main legislative texts are (1) the participation of citizens, (2) the transformation of the market, and (3) encouraging investment with a focus on the market as the main driver for energy transition. The transformation of the market involves citizen energy communities entering the market on the same conditions as other market players.

EU legislation is an important reference point for GENTE, as the GENTE toolkit is aimed at deployment in the EU, though not exclusively. It makes sense for the GENTE definition of an energy community to be compatible to some extent with the criteria which apply both to RECs and CECs, but deviations will also be considered.

3. Organizational Models

This section aims to deepen the understanding of organizational dimensions. Literature highlights that energy communities are diverse in terms of organizational models and legal forms (European Committee of the Regions et al., 2018:12-15; Boulanger et al., 2021; Dudka et al., 2023). The diversity of the organizational models can be traced to the different structural, organizational, and environmental dynamics (Kyriakopoulos, 2022; De Lotto et al., 2022). The following section summarizes firstly how organizational models have been categorized in EU related documents and secondly how the organizations models are categorized by researchers.

3.1. Classical categorization

The diversity of organizational models and legal forms in practice is commonly categorized in EU related documents as follows: energy cooperatives, (limited) partnerships, community trusts and foundations, housing associations, non-profit, customer-owned enterprises, public-private partnerships, public utility companies (see Hanna, 2017:4; European Committee of the Regions et al., 2018:12-15; IRENA, 2020:8; see Figure 1). These forms of organizational model are expanded on in this section.

- **Energy cooperatives:** This is the most common and fast-growing form of energy communities. Cooperatives are jointly owned by their members to achieve common economic, social, or cultural goals based on the democratic principle of "one member, one vote". This type of ownership primarily benefits its members. This type of arrangement is based on democratic principles, with each member having an equal say in decisions and an elected board overseeing the daily operations. Cooperatives rely largely on volunteers but can have paid staff. Compared to private companies, cooperatives require fewer administrative and legal requirements and offer moderate returns to investors. They are popular in countries where renewables and community energy are relatively advanced.
- **(Limited) Partnerships**: Partnerships are a common legal entity for community energy ownership and can be set up between individuals or legal persons. Depending on the liability for debts, they can take the form of joint and multiple liability partnerships or limited partnerships with a separate corporate structure. Bylaws of the partnership may establish limitations on ownership, determine how decisions are made, and stipulate who may participate. Hence, in partnerships, individual partners own shares in the community-ownership model. The key objective of a partnership is to generate profits for the shareholders, in addition to any other benefits of the project. Benefits include tax advantages, equal distribution of responsibilities and profits, and the ability to ensure decision-making is more democratic and transparent. Unlike cooperatives, partnerships may not operate on the basis of "one member, one vote", nor do partnership firms rely largely on volunteers, as cooperatives do. They may employ full-time staff to provide expertise needed for specific projects. In Germany, limited partnerships with a private company as a general partner are a commonly used structure, while in Denmark, energy partnerships often function under the title of 'association'.

- **Community trusts and foundations**: To guarantee that the advantages and profits from community energy projects are shared with the local community, community trusts and foundations are the most suitable ownership models. These organizations are created to benefit the wider community (as opposed to the financial gain of certain members) and enable the proceeds from the renewable energy project to be reinvested into the local area for particular local projects – this ensures that even those citizens who do not have the means to invest directly benefit from community energy.
- **Housing associations**: Housing associations can be an effective model for local energy, as they are able to finance community renewable energy projects and address social issues such as fuel poverty. However, the success of such a model is often limited by the lack of control that tenants have over decisions made by the housing association.
- **Non-profit, customer-owned enterprises**: Non-profit, customer-owned enterprises or organizations often follow the framework of cooperatives with the addition of specific rules. They are formed by investments from their members who are responsible for financing the organization but do not take back any profits. Profits are reinvested in projects focused on community development. Thereby legal structures for example can be used by communities that deal with the management of independent grid networks. This form is reported to be ideal for community district heating networks common in countries like Denmark.
- **Public-private partnerships:** Community energy ownership can take various legal forms depending on the national laws and circumstances. In Europe and North America, public and private limited liability companies are becoming increasingly popular as they provide investors with the ability to limit their liability and protect their private assets from losses. Local authorities can decide to enter into agreements with citizen groups and businesses in order to ensure energy provision and other benefits for a community.
- **Public utility company:** These forms of utility management, which are suitable for rural or isolated areas, are less frequent and are managed by municipalities that invest in and oversee them on behalf of taxpayers and citizens.

Model type	Strengths	Weaknesses
Co-operative (community-owned social enterprises)	- Co-operatives are voluntary and democratic (typically one member = one vote). - Common economic, social and cultural goals can be met.	- Raising sufficient capital can be a significant challenge. - Lack of familiarity with renewable energy and technical skills/ knowledge.
Community/local government hybrid model	- Local authorities can help to de-risk initial investment in projects, provide grants and collaborate on external funding bids. - Local authorities can provide practical planning support and share public land.	- Local authorities vary in terms of their understanding of the benefits of community energy. - Inconsistent application of planning rules and consent across different local authorities.
Community/ commercial developer hybrid model	- Increases community acceptance of larger scale installations, which offer potential for strong returns on investment. - Community organizations benefit from skills and investment of commercial developers.	- Cultural and operational differences between community and commercial organizations. - Communication barriers due to mutual lack of understanding and transparency.
Split ownership	- Supports multiple owners of a community renewables development on a single site, where a community organization owns one part of the development. - Other parts of the renewable energy facility might be owned by commercial developer, utility, independent power producer or investment fund.	- Community organization still needs to raise funds to construct or purchase part of the renewable energy development. - Community organization responsible for operating, monitoring and maintaining their equipment.
Minnesota's developer/utility subscription (Solar Gardens model)	- Community/residents do not need to provide their own location for renewables generation. - Subscribers receive electric bill and/or renewable energy credit, with long-term fixed utility rates.	- Delays to regulatory and interconnection process. - Consumers need more transparency and ability to compare developer terms on prices and contracts.

Figure 1 - Strengths and weaknesses of the different local energy ownership models (European Committee of the Regions et al., 2018:27; Hanna, 2017:4)

3.2. Contemporary investigations

The following section shows contemporary investigations of energy communities' organizational and business models with examples from Italy and France (De Vidovich et al., 2023; Dudka et al., 2023; Vernay et al., 2023). De Vidovich (et al., 2023) discusses a threefold subdivision of organizational models to implement renewable energy communities in Italy: public lead, pluralist, and community energy builders' model (Figure 2).

	CLUSTER 1 Public Lead Model	CLUSTER 2 Pluralist Model	CLUSTER 3 Community Energy Builder Model
Type of communities and stakeholders	Local public–private proposers; strong role of the public actor	Application of horizontal community models	Virtual intermediation between local projects and individual consumers
Generatedbenefits	Public–private partnership to create collective and local benefits	Citizen members and prosumers; coalitions of local actors	Alternative energy consumption models and action on consumer savings
Recruitment and participation processes	Predominantly top-down process and modus operandi	Predominantly bottom-up process and modus operandi	Heterogeneity of approaches between top-down and bottom-up

Figure 2 - Clustered organizational models of renewable energy communities in Italy (De Vidovich et al., 2023)

Dudka et al. (2023) provide an analysis of 164 French energy communities with regard to their ownership structure and institutional logic (Figure 3). This is described along two dimensions: the degree of citizen ownership; and the degree of direct participation. Building on Walker & Devine-Wright (2008) they identify a typology of four models - full citizen ownership, shared citizen ownership, citizen crowdfunding, and civic participation – and highlight how citizens can participate in different forms, namely directly, indirectly through a platform, directly but together with other entities, and indirectly through elected representatives and together with other entities. Following Dudka et al. (2023), in France, energy communities are characterized by strong citizen engagement in ownership and a strong community logic dominates.

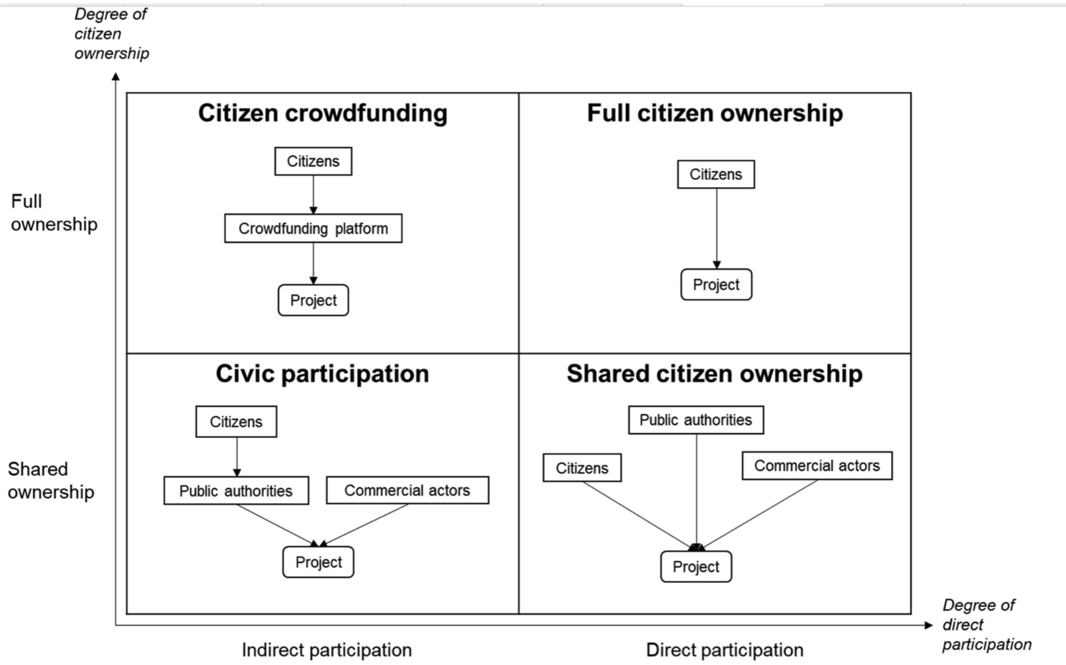

Figure 3 - A typology of energy citizenship in energy communities: ownership and participation (Dudka et al., 2023)

- **Full citizen ownership**: In the "ideal" community energy project (Walker & Devine-Wright, 2008), citizens fully own the production assets, take the leading role in the development of energy communities, and capture most of the benefits of energy production. This model allows citizens to participate in governance as well as raise awareness of energy issues within the broader local community. Energy communities that adopt this model are also driven, at least to some extent, by financial objectives. As equity is almost entirely owned by citizens, these energy communities are less likely to suffer from tensions between diverging institutional logics. However, a disadvantage of this model is that it may suffer from a lack of technical skills or financial resources, limiting the ability of projects to scale and reduce energy production costs.

- **Shared citizen ownership**: In the shared citizen ownership model, citizens are involved in the decision-making process of energy communities, but they share ownership with commercial actors and local public authorities. This model is characterized by a strong community logic, and it provides several potential advantages for all parties involved. For commercial developers, involving the local community can bring additional sources of funding and risk sharing, while for local communities, working with a commercial partner may provide an avenue for participating in a larger-scale renewable energy project. However, shared ownership may suffer from tensions between potentially conflicting objectives pursued by diverse investors or from a lack of trust between the parties.
- **Citizen crowdfunding** is an energy citizenship model in which citizens own project equity but gain financial participation through an online crowdfunding platform. This model allows for a larger pool of potential investors and a larger amount of equity and also works to create links with the local community. Benefits are allocated to activities to raise awareness of climate issues, and in some cases, local citizens are able to purchase shares. This model acts as a booster of social participation and could be defined as a crowdfunding platform that is both politically and socially motivated.
- **Civic participation** is a model of energy community design in which citizens do not own shares or actively participate in governance, but public authorities and commercial actors do. This model is characterized by a moderate presence of state and community logics and encourages the development of local community engagement activities. It may benefit from larger technical and financial resources due to the presence of commercial actors, as well as a higher level of legitimacy associated with the presence of local authorities. It has a relatively high median capital expenditure and is more diversified and able to deal with more complex technologies.

Vernay et al. (2023) describe five different types of energy community business models (ECBMs) that have emerged in France. The Local Integrated Energy Supply (LIES) is developed by local distribution companies and distributes and supplies energy through a legal entity. Collective Self-Consumption (CSC) involves joint production and consumption of renewable energy by consumers located geographically close to each other. Neighboring Energy Supply (NES) allows consumers to consume energy from a targeted newly built renewable energy asset in their vicinity. Citizen Energy Production (CEP) allows citizens to buy equity and gain access to project governance over local renewable energy projects. Finally, Cooperative Energy Supply (CES) allows consumers to identify the origins of their electricity and consume renewable electricity that is produced in France, with governance that follows cooperative principles. These initiatives are developed by a wide range of actors, including private, public, and civil society entities (ibid).

In summary, energy communities exhibit diverse organizational and ownership models that significantly impact their success. Energy cooperatives, characterized by joint ownership and democratic decision-making, are the most common and rapidly growing form. Each of the models proposed have strengths and weaknesses regarding ownership structure, profit distribution, democratic participation, and community benefits. Challenges in full-citizenship ownership models, such as limited technical skills, financial resources, conflicting objectives, and trust issues must be addressed for successful implementation and economic viability. The emergence of different energy community business models underscores the involvement of multiple actors in creating value for consumers, yet their economic viability remains fragile.

4. User engagement and participation

This section aims to deepen the understanding of two fundamental dimensions, that is the participation and the benefits associated with energy communities (cf. Sections 2.3.1 – 2.3.3. & 2.3.7), by addressing motivations.

4.1. Engagement: Users and communities

Soutar et al. (2022), who write about Smart Local Energy Systems (SLES), make a basic distinction between "users" and "communities", although this distinction is not always clearly defined elsewhere in the literature. Users are thereby defined in the sense of consumers, "actors (e.g. households, businesses and public sector organizations) interacting with technologies to consume or otherwise procure energy services within the boundaries of SLES projects" (Soutar et al., 2022). Clearly, there exist multiple types of users (or end-users), but the term is frequently used with reference to "domestic users", rather than users in business, industry, and public sector settings. Building up, "communities" thus refers to "a broader network of locally embedded individuals and groups with interest and/or influence in the move to a more local energy system", hence compared to users, communities go beyond direct engagement with energy services to potentially include participation in the design and development of local energy systems more broadly (ibid). The levels of engagement of participants in local energy communities vary, and there are different forms and levels of analysis of participation (Teladia & Windt, 2022) [1].

4.2. Motivations

Contemporary studies about local energy communities highlight the great diversity of individual motivations for participating in such communities, which can be broadly classified into five major categories: economic, environmental, social, political, and infrastructural. These major categories of motivations are often intertwined and overlap (Bauwens, 2016; Bauwens et al., 2022). Examples of these motivations can be seen in the development of renewable energy cooperatives, the adoption of renewable energy targets, the creation of green energy communities and the development of energy justice initiatives around the world.

[1] While literature on participation has evolved since the 1960s to address various emerging issues, Arnstein's heuristic ladder of participation framework (Arnstein, 1969) remains one of the most frequently cited papers and forms the conceptual basis of many of the existing participatory classification frameworks, also in the analysis of participation in energy systems (Teladia & Windt, 2022).

Objectives pursued by communities	Economic	Aims at financial or economic benefit for members of the community	Returns; financial benefit; economic advantage
	Social	Aims at social aspects in the community	Social capital; social cohesion; social ties; community building
	Environmental	Aims at climate and environment protection	Low carbon; emission reduction; renewable energy; ecological; environment; climate
	Energy autonomy	Aims at partial or full independence from the national energy supply system	Energy independence; fossil fuel independence; resilience
	Political	Aims at altering existing power relations and inequalities within energy systems	Empowerment; self-determination; political autonomy; co-determination; participation
	Infrastructural	Aims at improving the reliability of energy supply infrastructure	Grid balance; grid integration; integrated; energy management

Figure 4 - Objectives pursued by EC (Bauwens et al., 2022:3)

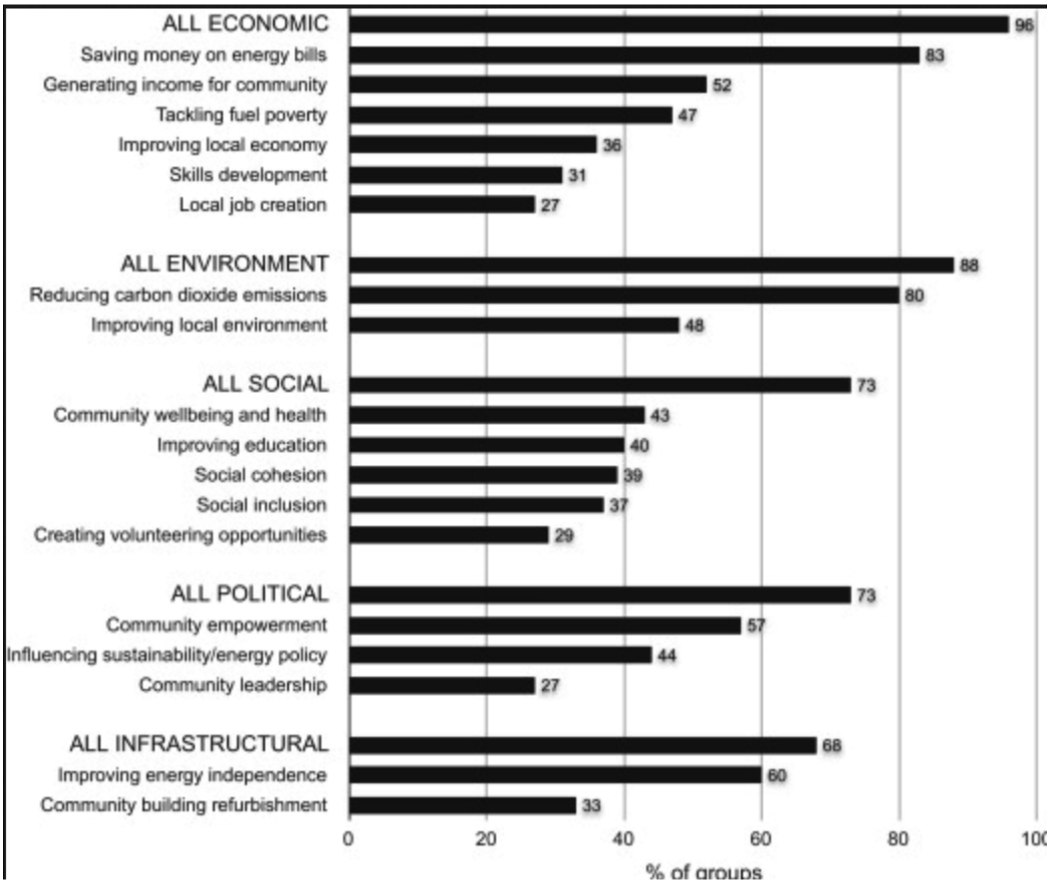

Figure 5 - Motivations (Seyfang et al., 2013)

In terms of their motivation and mission, the main objectives of these communities are according to Heras-Saizarbitoria et al. (2018): (a) the economic, according to which they aim to reduce energy costs or according to which they emphasize their cooperative nature, their efforts to strengthen the local economy and create local jobs, (b) the environmental, according to which they have a central role in promoting a new energy model and (c) the social, according to which they encourage specific forms of economic development, based on the empowerment of the local community. From another view authors summarized that their motivations and objectives can range from economic, environmental, social, political, and infrastructural (see Figures 4 and 5; Seyfang et al., 2013; Bauwens et al., 2022, p. 3; Karytsas & Theodoropoulou, 2022). Haf and Parkhill (2017) stress how cultural identity, language, and history can also affect the motivations of citizens (2017).

Economic motivations are typically driven by the desire to reduce energy costs. It is often mentioned in the literature as the most frequent gain motivation, participants thereby expected lower energy prices and saving money in the long run (Dóci & Vasileiadou, 2015).

Environmental motivations are typically driven by the desire to reduce emissions and pollution associated with traditional energy sources. According to a number of studies, participation in community energy projects is frequently motivated by environmental factors, such as a desire to support environmental sustainability and the energy transition away from fossil fuels and nuclear power toward renewable energy (Sloot et al., 2018).

Social motivations have been captured in the literature by the notion of **community building,** e.g. the desire to create regional value, to ensure regional energy supply, and to become more independent of energy companies (Koch & Christ, 2018) and are increasingly explored under the concept of "energy justice" or overlaps. Various studies have shown the importance of **community identity / social identification** (Goedkoop et al., 2022)**, trust** (Walker et al., 2010)**, and social norms** in order to achieve a high acceptance and willingness to participate in community energy projects (Kalkbrenner & Roosen, 2016). Socio-psychological literature on collective action shows that a strong social identification to a group fosters cooperative behaviors. This means stronger community identification and more interpersonal contact with other community members increases the likelihood that people become involved in a community initiative (Goedkoop et al., 2022).

Political Motivations: Motivations for participation can be also political, meaning supported by governmental instruments (Leonhardt et al., 2022) or driven by the desire to create a more equitable energy system ("**energy justice**") (Mundaca et al., 2018). Also, most of the contributions in Debizet & Pappalardo (2022:7) see local energy communities as "part of a movement of emancipation from the state and the large energy suppliers". Electricity is particularly associated with images of a centralized network that leaves little room for citizens and of energy producers, including renewable energy producers, led by multinational companies with purely profit-making motives. In contrast, the local is adorned with virtues: renewing links with the natural environment that surrounds the habitat, interdependence with neighbors based on the sharing of equipment, giving back 'power to the people' (ibid.). Shelton & Eakin (2022) systematically review articles that include the key concepts of "just transition" or "energy justice" and that examine advocacy in energy transition contexts. The six most common types of motivations were: procedural injustices, environmental degradation, energy ownership or control, recognition injustices, changed livelihood opportunities or economic conditions, and opposition to proximate energy infrastructure. Elmallah et al. (2022) reviewed over 60 "visioning documents" for energy transitions from community-based organizations in the United States and found six principles of a just energy future articulated in these documents: (1) being place-based, (2) addressing the root causes and legacies of inequality, (3) shifting the balance of power in existing forms of energy governance, (4) creating new, cooperative, and participatory systems of energy governance and ownership, (5) adopting a rights-based approach, and (6) rejecting false solutions.

Bauwens (2016) suggests that the **heterogeneity of motivations** should be considered in designing more effective supporting policies. He explains the heterogeneity of motivations by contrasts in terms of institutional settings, spatial patterns and attitudes to the diffusion of institutional innovations.

As this section shows, contemporary studies on local energy communities reveal diverse motivations among participants, including economic, environmental, social, political, and infrastructural factors. These motivations often overlap and intertwine. Economic motivations are driven by cost reduction, environmental motivations focus on reducing emissions and supporting sustainability, social motivations involve community building and energy justice, and political motivations aim for a more equitable energy system. Understanding the variety of motivations is crucial for designing effective policies to support these communities.

4.3. Demographic and socio-economic profile of end users in energy communities

The willingness to participate can be affected by citizens' current position in life. Some of the key demographic factors that influence citizens' willingness to participate are according to Koirala at al. "gender, age, education and income level" (2018). Evidence from a comparative choice and social acceptance experiment in Austria, Germany, Italy, and Switzerland in order to design local renewable energy communities shows there exist significant effects for "the age, gender, and education level of the respondent, and the presence of children in the household", whereas all other factors tested including "income, rural vs. urban residence, previous knowledge" and experience show no effect on social acceptance (Azarova et al., 2019).

Gender: Although extensive research has documented mutual interdependencies between gender relations and energy policy (Ryan, 2014), research on gender has been more or less unconnected to social science energy research. While initially attention was primarily paid to gender and energy in the context of developing countries, at the beginning of the 2000s, research started to focus also on industrial countries (Fraune, 2015). Following Tsagkari (2022) there still exists a major need for a gender-based approach in the assessment of local energy projects, as gender has been given little attention in the energy scholarship and especially during the post-implementation assessment of energy projects due to the belief that energy technologies are gender neutral and beneficial for the whole community (see also Allen et al., 2019; Feenstra & Özerol, 2021).

There exists a tendency according to some studies that male participation is higher than women's participation (Fraune, 2015; Taranis, 2018; Sebi & Vernay, 2020; Tsagkari, 2022). Fraune (2015), who studies citizen participation schemes in renewable electricity production, presents results which reveal statistically significant gender differences in the average ownership rate in citizen participation schemes, the average investment sum and leadership positions, whereby those of men are higher. In contrast, the findings on gender differences in the amount of capital assets invested per capita are inconclusive. Thus, the study does not provide evidence on the existence or non-existence of gender-related differences in individual preferences for involvement in citizen participation schemes in energy projects, but gives an indication of the existence of cultural, social and political factors affecting gender differences in participation in renewable electricity projects operated by citizens' associations. Another study of community renewable energy projects (CREPs) in France shows that a large majority of French CREPs' members are retired or elderly males with technical backgrounds from the highest socioprofessional categories and are especially those who are keen to invest time and capital in such projects (Taranis, 2018; Sebi & Vernay, 2020). Finally, in a similar manner Tsagkari's (2022) two case studies provide an indication that the rate of participation of women in the project design and implementation was significantly lower than that of men. While in the first case study women felt their voice was less heard throughout the process, in the second case women felt their voice was included sufficiently (Tsagkari, 2022). According to the study of Azarova et al. (2019) women are also more likely to prefer the status quo of local energy infrastructures compared to men, who are more likely to be interested in transitioning to sustainable energy infrastructures.

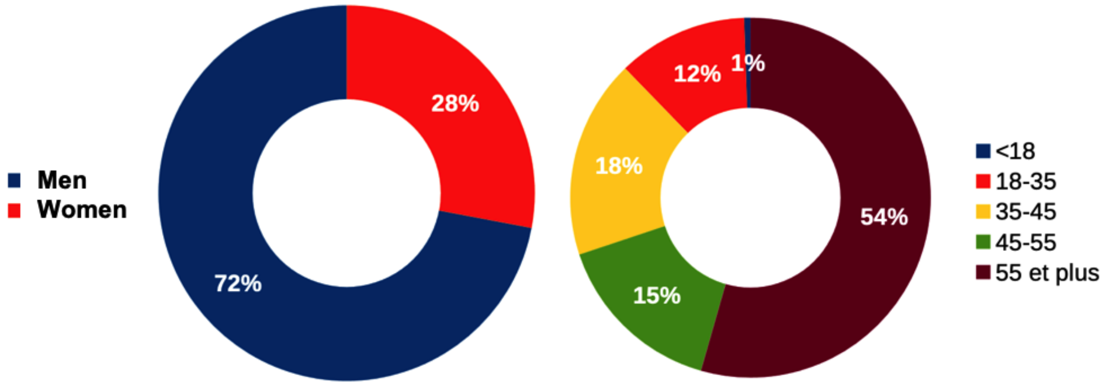

Figure 6 - Gender and age distribution of French CREPs' members (Taranis, 2018:4)

Age: As highlighted by studies (Taranis, 2018; Germes et al., 2021), in order to participate in an energy community, time is a crucial aspect, hence there is a tendency that older (55 plus), retired people are more likely to participate. Azarova et al.'s country comparative social acceptance study observes that compared to the group of 20–35 years-olds, being in the groups of 35–45 or 45–65 year-olds increases the probability of choosing the status-quo as the most preferred option by about 1.5% (2019). This means that middle-aged groups are thus generally less favorable towards transition to a renewable energy community, "though interestingly this effect is not present for the over-65 age group" (Azarova et al., 2019).

Education: Azarova et al. (2019) found that the level of education has a marginal effect on the likelihood of accepting a proposed renewable energy community. Compared to people with a university degree, persons with secondary or elementary school as their highest level of education are 2% more likely to prefer the status quo; however, this effect is only weakly statistically significant (at the 10% level) (Azarova et al., 2019). Studies have also shown correlations between geographical areas with higher levels of education and the emergence of energy communities projects (Ruggiero et al., 2019) and that households with a higher education level are more likely to financially invest in such projects (Štreimikienė et al., 2022).

Households and children: Studies show that there is a tendency for households with children to be more likely to be interested in renewable energy communities (Azarova et al., 2019) and show a higher probability to invest in renewable energy sources (Štreimikienė et al., 2022), which may suggest that parents consider a longer-term perspective in their decisions with respect to their community energy systems than others do (Azarova et al., 2019).

Economic household situation: In general, studies confirm the importance of financial incentives to adopt and engage in new energy solutions. For example, economic characteristics of households and perceived maintenance cost of renewable energies are strong statistically significant factors that affect consumers' intention of adopting renewable energy solutions (Sardianou & Genoudi, 2013) and higher household income increases the probability to invest such solutions (Štreimikienė et al., 2022).

To summarize, the demographic and socio-economic profile of end users in energy communities plays a significant role in their willingness to participate. Factors such as gender, age, education level, presence of children in the household, and economic situation influence the acceptance and engagement of individuals in renewable energy communities. Studies suggest that there is a gender disparity in participation, with men being more involved, and older retired individuals tend to be more likely to participate. Education level and household composition, particularly the presence of children, also impact interest and investment in renewable energy communities. Additionally, economic factors, such as income level, can play a crucial role in the adoption and engagement with renewable energy solutions. Understanding these demographic and socio-economic factors is essential for effective design and targeting of energy community initiatives.

4.4. What roles and forms of engagement of end users exist?

There are a number of different roles involved in delivering a successful energy project. These roles are sometimes filled by different people and sometimes people take on more than one role. Further these roles can evolve depending on the project plan. The key roles most often mentioned in the literature are firstly precursor actors often in the form of a (steering) committee, secondly the wider community and local citizens. Further the literature often mentions a third set of roles in the form of mentors/consultants or/and the wider political infrastructure of the community (Germes et al., 2021; seai, 2022). Others take a more differentiated approach in the stakeholder mapping (see Heuninckx et al., 2022).

Precursor actors & (steering) committee: Firstly, “precursor actors” (see Rogers, 2003) are people who initiate or lead energy communities (Debizet & Pappalardo 2022:5-6), generally groups of local citizens who steer the project as volunteers. This group is vital in the establishment and growth of the project. It often consists of around five persons, who should be enthusiastic and active and willing to invest a considerable amount of time (Germes et al., 2021).

The multiple skills and competences of this group are important factors in the implementation of the projects. Following Germes (et al. 2021) a large majority of steering members are “elderly men who were often retired, meaning that they had time to complete voluntary work” (Germes et al., 2021) although a common challenge is limited time for organizational work. Besides the fact that it is often hard to keep the same members in the steering group over time (due to time restrictions but also health) it is also not easy to motive and recruit new members for the steering committee, especially younger ones, although this demographic group is often perceived as one with a high potential (ibid). This challenge to participation is also confirmed by the study by Koirala et al. (2018). In this survey on willingness to participate, only 8% said they were prepared to accept substantial responsibility in steering the LEC[2] e.g. as member of the board, and 30% were willing to participate with minor responsibilities such as attending member meetings.

Besides time, precursor actors also have to engage and work with diverse stakeholders who may not be solely interested in the energy dimension. Tensions can develop between on the one hand "**precursors**" and "**experts**" from energy companies, who are easily integrated into project design and development, and on the other hand "lay" actors, who organize their participation in the community around a multitude of factors, of which energy is only one component (Debizet & Pappalardo 2022:5-6). This means when moving from the individual to the collective, actors come up against a wide range of interests and values, which can easily lead to conflicting situations as often reported on the micro-local level, the territorial as well the institutional level (Debizet & Pappalardo, 2022). While precursor households may experiment with their own or different consumption solutions enabling them to achieve efficiency and sufficiency objectives, the transition at the collective level can complicate a routine. Individuals therefore also have to take into account expectations and practices of other members of the energy community (Pappalardo, 2020). This risk is also highlighted by Koch & Christ (2018): The wish to participate actively in a community can result in a high willingness to volunteer for a local community energy project (Kalkbrenner & Roosen, 2016). Highly democratic and cooperative settings entail costs for collective-decision-making (Huybrechts & Mertens, 2014) and also have a high potential for risk of conflicts about goals, values and appropriate organizational approaches (Burchell et al., 2014) especially as the project grows and the motivations of participants become more diverse.

Wider community and local citizens: Beyond the steering group, acceptance, involvement, and engagement of wider community is a vital factor in realizing the energy community project and making it successful. Following Seai (2022), the wider community can involve individuals, householders, NGO's as well as businesses and community services. Germes et al. (2021) see it mostly limited to local citizens who can participate in joint activities or become shareholders. Most communities use several, usually less intense forms of engagement such as hosting local meetings, Facebook, newsletters and local newspapers to tell the local community energy story and invite wider participation in the project. Commonly the involvement of the wider community is reported to be one of the biggest challenges due to time restrictions and a lack of interest of local citizens in the project (Germes et al., 2021). Further, the individual engagement of participants in local energy communities can vary, while most prefer engaging only to a lower extent ("low-level participation") some appreciate very active participation. This means that while a high proportion usually declare their interest to support an energy community, only few are really willing to actively invest time and labor, regularly take part in organizational meetings and bring in new ideas for developing the local energy community (Rogers et al., 2008; Yildiz et al., 2015).

Mentors/local government/social networks: The third set of actors can include mentors/consultants (seai, 2022) and different actors such as local governments, intermediaries, umbrella organizations, and other energy community initiatives (Germes et al., 2021, see Figure 7). These actors are seen as an

[2] The participants were given the following options a) not willing to participate in energy projects, b) willing to participate without organizational responsibilities, c) willing to participate with minor organizational responsibilities such as attending members' meetings, and d) willing to participate with substantial responsibility of steering an energy project (ibid).

important factor for success. Through building and participating in networks, new collaborations can emerge, and information and knowledge can be shared, thus contributing to joint learning. Clearly, local governments can influence the development of energy communities through support, funding as well as through specific legislations (ibid).

Level of Engagement	Success Factors	Barriers
Initiative	• Motivation of steering group members • Skills: collaboration with local citizens and local organisations	• Failure of the first activity • Limited time of the members • Limited size • Recruiting new members for the steering group • Lack of expertise
Community	• Engagement of local citizens • Personal recruitment • Success of the first project	• High and unrealistic expectations concerning the number of participants • Lack of time for recruiting local citizens • Disinterest of local citizens in the subject • No clear view of the target groups
Municipality and province	• Having and using a social network • Support from local government • Support and guidance from intermediary organisations • Contact with other LEI	• Attending events is time consuming • Lack of support from local government • Lack of finance • Dependence on external funding

Figure 7 - An overview of the success factors and barriers influencing the development of LEIs (Germes et al., 2021)

The engagement of end users in energy communities involves various roles and forms of participation. The key roles identified in the literature include precursor actors and steering committee members who initiate and lead energy communities, the wider community and local citizens, and mentors/consultants or the wider political infrastructure of the community.

5. Case study “Am Aawasser”

5.1. The residential estate "Am Aawasser"

The following section describes the energy community “Am Aawasser”. Completed in 2020, the residential estate "Am Aawasser" in Buochs (CH) (https://www.am-aawasser.ch) comprises three apartment buildings with an integrated energy management solution. In 2019, it was awarded the Unterwalden Environmental Prize by WWF. The precursor actor is the entrepreneur who runs the three companies involved in Am Aawasser.

The **residential estate** consists of 26 residential units with 2.5 to 5.5 rooms and several ground-floor commercial spaces, occupying an area of 4,400 m^2. The varied size of the apartments contributes to a well-diversified neighborhood community. It is located near shopping facilities, public transportation stops, and the lake. Schools, kindergartens, childcare centers, restaurants, and daily necessities are also easily accessible. On the side facing away from the road, residents of the residential area have access to a car-free communal area with a children's playground, a boules court, and a community room.

Regarding the **energy concept**, the aim is to achieve a completely self-sufficient supply of renewable energy. The independent, CO2-neutral development already has an annual autonomy level of 90%. It combines hydroelectric power and photovoltaics with electricity storage. Located on the plot of the residential area is the "Am Aawasser" hydroelectric power plant, which generates energy for the residential community. Additionally, photovoltaic systems on the rooftops produce electricity. Excess energy, primarily generated during the summer months, is stored in batteries, or fed into the Nidwalden power grid.

The **energy management** system includes smart home solutions and controls the energy and building technology, ensuring the centralized monitoring and billing of energy flows. An innovative energy budget, included in the rental price has been implemented to raise awareness among residents about conscious consumption. Through the accompanying app, residents can monitor in real-time their energy usage and see how much energy they have already consumed or are currently using. The interactive interplay between the energy budget and the app aims to promote energy consciousness in a user-friendly and engaging manner.

The **legal organization** of the project involves a multi-part holding structure. One limited company owns the land and buildings, while a second serves as a contracting partner, owns the production assets (solar panels and the hydroelectric plant) and sells energy and water to the tenants. Both companies are controlled by the private individual and initiator who essentially operates the entire project. He, with others, also manages the property through a third company.

5.2. End users in Am Aawasser

The following section presents an analysis of interviews with residents of the Am Aawasser estate. Four semi-structured narrative interviews (Kvale 2007) were conducted with residents in November 2022. The interview guide contained questions on motivations for joining the Am Aawasser community, community aspects, energy use practices and attitudes towards data privacy and automated load scheduling of household devices. In the following content analysis, we concentrate on motivation for joining the community, energy-saving practices, and the community dimension. Overall, the case study provides an example of an energy community with moderately idealistic end users. While energy saving practices are regarded as having some importance, they are hardly the primary driving factor for joining the community.

Socio-economic background: Residents from four different apartments (three couples and one individual) were interviewed. The duration of their residency ranged from recently moving in to approximately two years. They were in their middle years; the majority of the participants fell within the age range of 41-50 years. In terms of educational backgrounds, all participants had completed either vocational training or commercial training/trade school. Additionally, some participants had higher professional or vocational education. In terms of employment, a gender difference is observed, with women predominantly working part-time or being housewives, while the males worked full-time. All participants were of Swiss nationality.

Motivations to join and attitudes towards sustainability: The interview partners varied in their perspectives on sustainability, ranging from making limited consumer choices to active engagement in sustainable practices and considerations of sustainability in daily decision-making. Based on the interviews, it appears that the energy concept was not the primary reason for them to choose the residence and join the energy community. While energy-related aspects played a role in their decision-making process, they were not the main driving force behind their choice. Other factors such as location, building features, infrastructure, personal interests, and the appeal of the community were more significant in their decision to join.

Energy saving practices: The participants had varying levels of engagement with their energy use. While some consciously and actively tried to reduce consumption, e.g., by monitoring energy budgets, others did so less. The app was utilized by all participants. While some primarily used it for basic functions such as turning off lights and operating the washing machine, others made more extensive use of the app, including controlling blinds, ventilation, temperature settings, and monitoring overall energy consumption. The app was seen by some as a valuable tool in managing various aspects of their daily routines and enhancing energy efficiency within their homes, but the app's feedback did not seem to significantly influence energy consumption behaviour. Similarly, the participants demonstrated a range of behaviours and attitudes towards energy consumption and saving, with some actively implementing energy-saving practices and others having fewer specific strategies in place. Regarding car and electric car usage, the participant households had mixed behaviours. All but one used a car with a combustion engine. One interview partner did not use the shared electric car, one couple had registered for the electric car and planned to try it soon. Another couple had been using the shared electric car frequently and intended to purchase their own electric car the year after. In terms of electricity consumption, there was a general awareness of turning off lights when not needed and avoiding unnecessary energy use. For warm water usage, there was a focus on sufficiency practices. Participants emphasized taking showers instead of baths and using economy settings or turning off the shower when soaping up to save water and energy. One couple specifically mentioned using the economy mode and adjusting bathing habits to conserve energy. Care was also given to heating approaches, e.g. setting different room temperatures, with lower temperatures in bedrooms and higher temperatures in living areas.

Intention-action-gap: In summary, adopting a critical reflection perspective, the interviews revealed a tendency towards an "intention-action gap" whereby there existed an inconsistency between individuals' professed beliefs (that energy-saving practices are important) and their actual behaviours. This phenomenon can be seen considering two factors, namely living space consumption and the use of fossil fuel-powered cars for transportation, which are major drivers of energy consumption and CO_2 emissions. Most (or all?) participants relied on fossil fuel-powered cars for transportation and all of them consumed a substantial amount of living space. According to the 2019 data from the Federal Statistical Office (BFS), the average living space for households with two or more individuals was 40 m2. However, the living space per person in the interviewed households ranged from 33 to 58 m2, with three out of the four households exceeding the national average.

Community dimension: Regarding interaction with other members/tenants and cohesion within the community, the participants' experiences varied from very little interaction to a high appreciation of social cohesion, especially the occasional community events on Saturdays. However, none of the interviewed partners engage in conversations with their neighbors regarding energy or their energy consumption habits.

5.3. Am Aawasser: Exploring the Dimensions of an Energy Community

This section provides a brief summary of the dimensions of Am Aawasser as an energy community (see Table 3). While the size of the interviews sample is small (7 persons), based on knowledge gained from site visits, we can assumed that the sample is representative of the whole residential estate. In summary the profile of end users is influenced more by the housing offering rather than the energy community itself.

The Am Aawasser community aims to achieve a largely self-sufficient supply of renewable energy (main motivation) by combining generation through photovoltaics and a hydroelectric plant (main activity). In terms of organizational and legal models Am Aawasser is clearly business-led, as the initiator (who is thus the precursor actor) is the sole private owner and sells green energy to the residents for profit. Technically, the community is organized as an internal grid with one connection to the public grid.

The energy project Am Aawasser is constituted as a legal entity, as a limited company which owns the energy infrastructure. It fulfills the criteria of generating renewable energy and of a connection to the public grid. Finally, members are geographically co-located. Membership is in effect limited to one member, the small enterprise which owns the energy infrastructure. The end users are not, however, involved as members in this energy project, only as consumers. This means that regarding “organizational/governance structure”, Am Aawasser falls under the option “one member has full control”. As it is not possible to join the energy community and become a member with voting rights, Am Aawasser is not a community in the sense of individual consumers having the opportunity to participate in ownership and control of the community. For Switzerland, this is not an unusual case but rather the norm for the increasingly common local energy projects organized as self-consumption communities (ZEV) with tenants as end-users with no control or ownership (Dorschner et al., 2020).

This arrangement seems to align with the residents' moderate desires and motivations for sustainable energy usage and development. As indicated, the energy concept of the residential estate is not the primary motivation for being a ‘member’ of this energy community; instead, the comfortable infrastructure of the building in general is the primary attractor. Social motivations also appear to be moderate based on limited interviews. Community building and cohesion are facilitated through occasional meetings on Saturdays, led by the initiator. Although there is some social cohesion within the residence, energy issues are not central to residents' identity and interactions with neighbors. Nonetheless, the objective of achieving a self-sufficient supply of renewable energy serves as a clear identity factor for the residential estate.

Table 3 - Characterization of Am Aawasser

Dimension	Option
Legal entity	Yes, limited company
Limited to smaller actors	Yes, one small enterprise
Connection type	Single connection to public grid
Geographical scope	Very local, 3 adjacent buildings
Types and scale of technology	PV, hydroelectric, battery storage, heat pumps, heat storage in water tanks
Main activities	generation and local optimization
Main motivation	making profit and promoting the energy transition
Revenue model	revenue from selling energy
Organizational/governance structure	Control by one member
Main actor	For-profit business

6. A GENTE proposal for energy community description

With our review of the research literature, we have opened up a broad variety of analytic dimensions and possible characteristics of energy communities, as presented in Table 2. This complexity needs to be reduced to some extent to set out a focus for GENTE, i.e. to define what kinds of energy communities GENTE is targeting. The aim of this chapter is to reduce the complexity within the research literature and to provide a useful description of energy communities for GENTE. We do this in three steps. The first step defines characteristics which are mandatory from the point of view of GENTE (see Table 4). This allows us to formulate a definition of energy communities in GENTE. The mandatory characteristics are derived in two ways. On the one hand they reflect which technologies GENTE is developing and the aims of the project. On the other hand, they incorporate elements of EU legislation (see Section 2.5), to ensure a certain level of compatibility.

In the second step, we define eight dimensions on which energy communities relevant to GENTE vary. This involves reducing the number of dimensions and options presented in Table 2 to a more manageable set of dimensions. This is done by merging dimensions and omitting some we see as less relevant. Table 4 presents analytic dimensions relevant to GENTE. We discuss each of the columns in Table 4 in the text which follows.

In the third step, we reduce the complexity further and propose four energy community archetypes. These archetypes correspond to typical combinations of characteristics which fulfil two criteria: they require the types of technologies which GENTE is developing, and they are common in European countries now or are likely to become common over the coming years.

6.1. Mandatory characteristics

Generation of renewable energy

Though GENTE is open regarding technology and core activities, the technologies developed in GENTE are aimed at communities with at least some amount of generation of renewable energy.

Connection to public grid

A further mandatory technical characteristic is that energy communities within GENTE are connected to the public grid, as only then federation of communities or provision of external services are feasible options.

Legal entity

As required by EU legislation, an energy community within GENTE must be organized as a legal entity, e.g. an association, trust, cooperative, for-profit company, etc.

Table 4 - Analytic dimensions for energy communities in GENTE

<table>
<tr><th colspan="8">Mandatory characteristics</th></tr>
<tr><td colspan="8">Generation of renewable energy
Connected to public grid
Legal entity
Limited to “smaller actors” (individuals, municipalities, associations, SMEs)
Active participation of end users</td></tr>
<tr><th colspan="8">Optional characteristics</th></tr>
<tr><th rowspan="2">Types and scale of technology</th><th rowspan="2">Connection type</th><th rowspan="2">Main activity</th><th rowspan="2">Main motivation</th><th rowspan="2">Revenue model</th><th colspan="2">Governance structure</th><th rowspan="2">Main actors</th></tr>
<tr><th>Distribution of control</th><th>Access</th></tr>
<tr><td>All and any permitted</td><td>Single connection to the grid
Virtual connection</td><td>Generation
Local optimization
Energy services for grid</td><td>Benefits for the local community
Promoting energy transition
Increasing self-consumption
Increasing grid reliability
Reducing energy consumption
Reducing energy costs
Making profit</td><td>Reducing energy costs (no revenue)
Revenue from selling energy
Revenue from providing external services</td><td>One member – one vote
Voting rights proportional to investment (limit on maximum investment)
Voting rights proportional to investment (no limitation)
Control by one member</td><td>Access open to all
Access restricted</td><td>Individuals
Civil society organizations
Public bodies
For-profit businesses</td></tr>
</table>

Limitation to “smaller actors”

In line with EU legislation, members of the energy community may be individuals, associations and other civil society organizations, municipalities, and small and medium enterprises (SMEs). Large enterprises and enterprises whose main business is in energy are excluded from membership and thus decision making, though they may interact and cooperate with energy communities.

Active participation of end users

Many definitions of energy communities require that end users (i.e. the people who consume the energy produced) are involved in decisions about the energy community and/or own a share in the energy community. For GENTE we assume that end users will have the opportunity to participate in decision making or in shaping the energy community in some way. This participation may be more limited than formal voting rights or ownership but will be more extensive than what end users of a large utility company generally enjoy.

Based on the mandatory characteristics and our prior discussion, we propose the **following definition of energy communities for GENTE**:

An energy community is an energy project involving consumers and/or prosumers who share renewable energy generation units (community as technology), live in a shared place or have a shared interest (community of place/interest) and have some level of control over or participation in the project (cf. Schram et al., 2019, p. 2; Van Veelen, 2017, p. 5; Verde et al., 2020, p. 5). We assume energy communities will be connected to the public grid, organized as a legal entity and have only “smaller actors” as members.

6.2. Optional characteristics

Technology

All *technologies* for renewable generation, distribution, storage, and energy management are in principle permitted. For generation, this includes roof-top and façade PV, open-space PV, wind farms, bioenergy, biomass, biogas, hydropower, CHP (combined heat & power), waste heat and solar-thermal installations. Storage includes batteries, power-to-x (hydrogen, methane, heat) or seasonal thermal storage. Distribution includes microgrids (low voltage, DC), public grid and low or high-temperature district heating networks. Appliances typically integrated include electric vehicles (EVs), heat pumps, smart meters, and flexible appliances. For GENTE, not all technologies are equally relevant, but there is no reason to exclude technologies *a priori*. This dimension remains open.

Connection type

This technical dimension refers to how each building in an energy community is connected to the grid and to each other. We distinguish two options: *single connection to the grid* and v*irtual connection*. In the case of a single connection to the grid, buildings within the energy community are physically connected to one another (as in a micro grid) but have only one common connection to the public grid. From the perspective of the public grid, these buildings are all behind one metering point. In the case of a virtual connection, each building within the energy community is connected to the public grid directly. The energy assets are coordinated and connected through individual smart meters and a datahub.

Main activity

As the *main activity* of a community, this dimension offers the options *generation*, *local optimization* and *energy services for the grid* and *the combination of local optimization and energy services for the grid*. This amounts to a simplification of the dimension key function proposed by Kubli and Puranik (2023).

Main motivation

The *main motivation* for an energy community is the "the driving force behind the energy community" (Kubli & Puranik, 2023, p.4), the core reason why members join and invest effort in the project. The first option is *benefits for the local community*, where the aim of the energy community is to benefit a local association or a place-based community beyond the energy community or to boost the local economy. The second is *promoting the energy transition*, where environmental concerns are the main focus. The option *increasing self-consumption* can be connected to issues of energy costs, energy autonomy and/or transparency of energy sources. The next option *increasing grid reliability* is related to improving the quality of electricity provision either in areas where reliability is low or where increasing renewables generation threatens to destabilize the grid in the future (Kubli et al. 2023). The option of reducing *energy consumption* implies energy communities "focus their activities on the demand side" (Kubli et al. 2023), either driven by environmental, autonomy or cost rationales. The option *reducing energy costs* is a motivation which can be reached in different ways, e.g. by local energy optimization. Finally, *making profit* is not explicitly defined as an option in the literature reviewed above. This is for good reason, as many authors deem a community whose *main* motivation is to make profit will not be able to harness the energies of grassroots participation, community identification, empowerment through energy citizenship etc. (e.g. Bauwens et al. 2022). Similarly, the EU legislation on CECs and RECs excludes communities which are for-profit. We include it here as we define energy communities in GENTE more widely regarding this aspect. While the GENTE toolkit will be able to serve energy communities which are not profit-driven, we include profit-driven communities within the space of projects that GENTE targets.

Revenue model

The *revenue model* specifies the core economic proposition of an energy community, how it becomes economically viable. The options specified are largely based on Kubli and Puranik (2023), though some options have been omitted for simplification. Our options are *reducing energy costs (no revenue)*, *revenue from selling energy* and *revenue from providing external services*. The first option does not aim to generate revenue from actors external to the energy community but provides economic gain to members by reducing their prior costs. The two other options generate external revenue flows, in the one case by selling energy, in the other by providing external services, typically to a DSO.

Governance structure

In the literature, many dimensions of *governance structure* are described. One is the legal entity used to organize the energy community. Though this provides some information on governance structure, decision-making structures can vary between two limited companies or two cooperatives, as Hicks and Ison (2018) point out. We follow Hicks and Ison (2018) here in using the *distribution of voting rights* as one of the central dimensions for defining governance structure. The options on this dimension are *one member – one vote*, *voting rights proportional to investment (limit on maximum investment)*, *voting rights proportional to investment (no limitation)* and *control by one member*. Limits on maximum investment prevent one member taking full control of an energy community, e.g. where no investor is permitted to hold more than 33% of voting rights.

Main actors

We consider the *main actors* involved in an energy community to be the ones who drive the creation of the community and/or control it, while other actors can be involved as members or partners in less decisive roles. The options used are loosely based on those used by Hicks and Ison (2018; though simplified somewhat by omitting the dimension of locality). The options do not specify more concrete actors as Kubli and Puranik (2023) do, but rather remain more abstract. We define *individuals*, *civil society organizations*, *public bodies* and *for-profit businesses*. Actual energy communities nearly always involve actors from several or all of these categories. Municipalities often play a decisive role in the success of energy communities in cooperation with other actors (Schmid et al., 2020; Sebi & Vernay, 2020). However, we think which actor initiates and drives a community is a core element which shapes the community.

6.3. GENTE Archetypes

While the mandatory and optional characteristics reduce the complexity seen in the literature considerably, the number of possible combinations in Table 4 remains large. In this section, we reduce the complexity even further by describing four archetypes of energy communities (see Table 5). The archetypes fall within the mandatory characteristics defined above. Beyond that, we have chosen three dimensions which we take to be central:

- connection type
- main activity
- governance structure

We also reduce the options on these dimensions to simplify further. On the *connection type* dimension, we distinguish the two options *single connection to the grid* and *virtual network*. The first refers to energy communities where all consumers, prosumers and energy generation assets are behind one single connection to the grid. This in turn means individual consumers within the community are not *directly* connected to the grid. The second option implies consumers, prosumers and producers who are members of an energy community are all directly connected to the public grid and are connected to each other by a digital infrastructure (smart meters, hub etc.).

The *main activity* is either local optimization (which may include internal maximizing of self-consumption but also selling energy to the grid) or *providing services* (which may include selling energy, flexibility, or storage to external customers).

On the *governance structure* dimension, we simplify the dimension used above to retain only two options *control by one or few members* and *widely distributed control*. Widely distributed control can be thought of as governance structures such as cooperatives, with a one member – one vote principle, or limited companies with many shareholders. Control by one or few members will generally mean control by a business, which is why we consider these communities business-led as opposed to community-led in the case of widely distributed control.

Table 5 - GENTE archetypes

Archetype name	Connection type	Main activity	Governance structure
1 Community-led local optimization community	Single connection to the grid	Local optimization	Control widely distributed
2 Virtual community-led local optimization community	Virtual connection	Local optimization	Control widely distributed
3 Business-led service-focused community	Single connection to the grid	Providing services	Control by one/few members
4 Virtual business-led service-focused community	Virtual connection	Providing services	Control by one/few members

To give more depth to these archetypes, the following section describes what we consider to be a typical constellation for each archetype. We also add a variant to each archetype, which differs from the main archetype on the governance dimension.

Archetype 1: Community-led local optimization community

This archetype typically involves small prosumers, such as private homeowners with PV installations, joining together to create an energy community. Their aim will typically be to increase self-consumption and thus reduce energy costs through local optimization. The energy community will have a single connection to the grid (such as local grids in the Netherlands [Tarpani et al., 2022] or self-consumption communities (ZEV) under Swiss law [Dorschner et al., 2020]). The geographical scope will typically be small, e.g. a few neighboring streets. The municipality or local businesses may be involved, but the homeowners will be the driving force behind the community and have control. As a legal form of organization, they may choose e.g. a cooperative structure or an association, ensuring a wide distribution of voting rights.

Variant **archetype 1a:** A variant of archetype 1 is a business-led local optimization community, where one or a few members control the community and generally seek to generate financial profits. In this variant, the primary decision-makers are usually a for-profit corporation, which guides the community's direction instead of the homeowners.. The company will provide energy to community members (end users) and to the grid, aiming to generate energy by exploiting the differences between prices paid and different times. End users may not be homeowners but tenants, as in the quite common ZEV arrangements in Switzerland (Dorschner et al., 2020) where tenants buy energy from the self-consumption community (ZEV) the landlord has established. The Am Aawasser project can be considered a community of this kind.

Archetype 2: Virtual community-led local optimization community

This archetype differs from archetype 1 primarily by connection type: the members/buildings of the community are connected virtually. Again, homeowners will be the driving force behind the community and have control. There will be extra technical requirements for the management of the virtual network which may be a service the energy community purchases from a company. The geographical scope is more open than in archetype 1, but in some legislations, all end users will have to be located in the same sub-net of the public grid. In some EU countries communities of this kind are currently possible (e.g. Italy, di Silvestre et al., 2021), in Switzerland they will become possible if the proposed law on renewable energy currently in parliament is passed (Bundesgesetz über eine sichere Stromversorgung mit erneuerbaren Energien 2021).

Variant **archetype 2a**: a variant of archetype 2 is a business-led virtual optimization community, where one or a few members control the community and generally seek to generate financial profits.

Archetype 3: Business-led service-focused community

This energy community archetype will typically be initiated, organized, and controlled by a for-profit business with an aim to generate revenue from offering flexibility services to the grid. The main activity consists of aggregating generation and/or flexible loads of community members. With a single connection to the grid, this community could for example consist of a large residential or mixed-use estate with generation and flexible loads.

Variant **archetype 3a**: a variant of archetype 3 is a community-led service-focused community, where control is widely distributed among members (end users). A community that begins as an archetype 1 may evolve into archetype 4a, provided the required technology and favorable regulatory and market opportunities are present, thus offering the community with an extra source of revenue.

Archetype 4: Virtual business-led service-focused community

This energy community archetype will typically be initiated, organized, and controlled by a for-profit business with an aim to generate revenue from offering flexibility services to the grid. The main activity consists of aggregating generation and/or flexible loads of individual community members. The individual assets/members will be connected virtually, in contrast to archetype 3. The geographic scope of the community may be limited - e.g. within the public grid belonging to one public utility - but potentially could be very broad.

Variant **archetype 4a**: a possible variant of archetype 4 is a community-led virtual service-focused community, where control is widely distributed among members (end users). We take this variant to be unlikely.

7. Conclusion

This report has attempted to give an answer to three basic questions: How are energy communities described and defined in the research literature? Which energy communities are relevant to GENTE? Which organizational models, patterns of engagement and social profiles of end users exist? The results of the first two queries are summarized below. We then discuss the final question in light of the co-design processes planned in GENTE and ask how the answers can support these.

Energy communities: Dimensions, definitions and archetypes

Based on a literature review, 21 dimensions used in the literature to describe energy communities were identified (see Table 2). This rich complexity was reduced to **8 analytic dimensions** in Table 4. These are *types and scale of technology, connection type, main activity, main motivation, revenue model, governance structure* and *main actors*. These eight dimensions are useful for creating relatively succinct descriptions of energy communities, for the purpose of comparison and identifying e.g. technical, organizational, or regulatory needs.

While this report did not aim to create a definitive and final definition of energy communities, we did find it necessary to mark out which subset of the huge and diverse realm of energy communities described in the literature is of interest to GENTE as a project. This led to **5 mandatory characteristics** (see Table 4). The energy communities which GENTE targets thus all (1) generate renewable energy, (2) are connected to the public grid, (3) are organized as a legal entity, (4) limit membership to “smaller actors” (individuals, municipalities, associations, SMEs) and (5) encourage active participation of end users. The **working definition** of energy communities for GENTE proposed in this report is as follows (see Section 6.1):

For GENTE, an energy community is an energy project involving energy consumers and/or prosumers who share renewable energy generation units, who live in a shared place or have a shared interest and have some level of control over or participation in the project. We assume energy communities will be connected to the public grid, organized as a legal entity and have only “smaller actors” as members.

The **4 archetypes** (with 4 four sub-variants) developed in Section 6.3 (see Table 5) are intended to provide a more tangible set of types of energy community to facilitate discussion within the project and help align technology development. The main archetypes are (1) Community-led local optimization communities, focused on local optimization and with a single connection to the grid (2) Virtual community-led local optimization communities, with a virtual connection type, (3) Business-led service-focused communities (with a single connection to the grid) and (4) Virtual business-led service-focused communities.

Engagement, social-economic profiles and the co-design process

A number of insights brought together in this report can and should be fed into the co-design process planned later in the project. The report emphasizes the importance of effective engagement and collaboration among precursor actors, the wider community, and various stakeholders to ensure the success of co-design processes and other GENTE activities. Understanding the challenges, motivations, and expectations of different actors will be crucial for overcoming barriers and fostering active participation in energy projects.

The demographic and socio-economic characteristics of end users in energy communities also have implications for the co-design process and other GENTE activities. The research suggests that **gender** can influence participation in energy communities. There is a tendency for higher male participation compared to women, particularly in leadership positions and regarding investment sums. GENTE's goals regarding diversity mean we should aim to ensure inclusivity and equal participation in the co-design processes. Given the insights from the literature, we should strive to identify and address any barriers or biases that may deter women from actively engaging in the process. **Age** is another factor to be taken into account. The willingness to participate in energy communities tends to be higher among older individuals, particularly those who are retired. Understanding the preferences and concerns of different age groups will be important for designing and tailoring the energy project and the co-design process to meet their specific needs and interests. **Households with children** tend to show more interest in renewable energy communities and have a higher probability of investing in renewable energy sources. Parents may consider a longer-term perspective when making decisions regarding community energy systems. This highlights the importance of considering the needs and motivations of households with children in the co-design process and GENTE activities. Finally, the economic characteristics of households play a significant role in the adoption and engagement of energy solutions. As perhaps to be expected, higher **household income** increases the probability of investing in renewable energy projects. While we expect our co-design site to be in an area with relatively wealthy households, care should be given to identify and enhance the participation of less affluent households within the project perimeter. We may try to provide financial incentives and ensure affordability so as to contribute to the success of the design process regarding inclusivity and size.

Finally, the choice of organizational and ownership models and legal forms for energy communities has implications for decision-making, profit distribution, community engagement, and the overall success of energy projects. The co-design process should consider the strengths and weaknesses of different models and tailor the approach to accommodate diverse the legal requirements and the (possibly diverse) interests of the households and other stakeholders.

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