Energy Communities Coming of Age
Developing a Tool to Monitor Maturity and Scaling

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Energy Communities Coming of Age

Developing a Tool to Monitor Maturity and Scaling

SCCALE 203050 Deliverables 2.1 and 2.2

Work Package 2: Research and Academic Validation

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Executive summary

This report presents Deliverables 2.1 and 2.2 of the Horizon 2020 SCCALE 203050 project (Sustainable Collective Citizen Action for a Local Europe). The aim of this project is to scale the growth of energy communities - or "Renewable Energy Communities" according to the EU Renewable Energy Directive (RED II) - across Europe in the areas of energy efficiency, renewable energy production, district heating in households and non-residential buildings. This report is the first deliverable of Work package 2 (Research and Academic Validation) which seeks to gain a better understanding of how collective citizen actions in sustainable energy develop, grow, mature - in other words, how they come of age. This will be done by analysing, monitoring and evaluating experiences of collective citizen action and community engagement in the domains of sustainable energy (i.e. renewable energy, energy efficiency, and energy conservation).

This report first presents the results of a literature review (i.e. Deliverable 2.1) – using both academic and grey literature - on energy communities and collective citizen actions contributing to sustainable energy transitions. However, the report goes beyond a literature study. Instead, it was developed as a collaborative effort between the research team at Delft University of Technology and community energy experts and practitioners using multiple interactive and feedback meetings.

The central aim of this report is to generate insights into the actions and activities energy communities and citizen collectives undertake to develop and mature their organisations with the objective to scale, achieve transformative change, and make both a social and environmental impact. The report maps state of the art insights into collective citizen actions at the neighbourhood level, targeting energy efficiency and renewable energy technology measures alike. Moreover, it addresses relevant theory and good practice on actions and activities that energy communities can pursue, partly based on theory and partly based on case studies. In addition, the report also takes into account issues like energy poverty, energy democracy, energy justice, social inclusiveness, citizen engagement, multi-stakeholder management in neighbourhoods, the use of digital tools, and data protection (to cope with increasing cybersecurity issues).

In addition, the report presents the development and design of a monitoring tool (Deliverable 2.2). The Development Progress Tool uses knowledge from the literature study. This is firstly used to elaborate the energy community maturity scale and framework as developed under the Horizon 2020 COMPILE project (Seebauer et al., 2022). The elaborated maturity index forms the conceptual basis and framework to develop a monitoring tool. The latter will be implemented, tested and validated among the five demonstration pilots of SCCALE 203050 in 2022-2023.

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1. Introduction

Today, there are over 1.25 million European citizens involved in community energy (REScoop.eu, 2023). These citizens might begin as groups of neighbours, friends or families who start at the kitchen table sketching an idea. They enthuse and motivate others, strive to gain support in their wider community and from their municipality, and then they act. They might start a grassroots renewable energy initiative, decide to adopt the cooperative business and organisational-legal model, and co-design, co-produce, distribute, trade and implement sustainable energy projects in their immediate surroundings. Most of the readers of this report are familiar with one or more success stories on how energy communities started and thrived.

Much information on energy communities - from here on defined as "Renewable Energy Communities" (RECs) according to the EU Renewable Energy Directive (RED II) - has been codified in academic and grey literature in recent years. In the present report this body of literature is reviewed with the aim to map critical insights into how energy communities - and more in general - citizen energy collectives (i.e., RECs) - emerge, develop, mature, and can be scaled. Special attention is paid to the actions and activities RECs undertake along the way, and are classified in different stages of development in their maturing process. Therefore, the central aim of this report (i.e., Deliverables 2.1 and 2.2 to the Horizon 2020 SCCALE 203050 project) is to generate insights into the actions and activities energy communities and citizen collectives undertake to develop, grow and mature their organisations with the aim to scale, achieve transformative change, and make both a social and environmental impact. In addition, the generated knowledge from the literature study (i.e., Deliverable 2.1) will be used to reflect on and contribute to the maturity scale and framework as developed under the Horizon 2020 COMPILE project[1] as tools to assess the maturity and growth of energy communities (Seebauer et al., 2022). In addition, the conceptual basis and framework are presented that are key to developing a monitoring tool (i.e., Deliverable 2.2 to the Horizon 2020 SCCALE 203050 project).

This report does not result from a systematic literature study in a strict sense only. Instead, it was developed as a collaborative effort between a research team at Delft University of Technology on the one side and community energy experts and practitioners on the other. Key themes were identified, narrowed down, and evaluated in several online meetings as

[1] The development of the maturity scale and framework that is presented in this document has been conducted within the COMPILE project. It only reflects the COMPILE Consortium view and the European Union is not responsible for any use that may be made of the information it contains. The maturity scale and framework, and their content are the property of the COMPILE Consortium. The maturity scale and framework are licensed under a Creative Commons Attribution 4.0 International License (CC-BY). https://creativecommons.org/licenses/by/4.0/

well as in an on-site co-creation workshop in Brussels in September 2021 with members of the SCCALE 203050 project consortium. Opinions, questions and priorities around these key themes can be found in the appendices. Moreover, there have been continuous feedback loops of the draft version between the authors and the REScoop.eu consortium leading team as well as other community energy experts and practitioners. Although this report presents results of a literature study that maps the state of the art in community energy research, it must be read as a living document, since collective action and community energy is an ever evolving field, with numerous demonstration pilots, living labs, and policy experiments across Europe and the world, which means that such a report needs continuous monitoring and updating.

This report was written to inform community energy practitioners, local policy makers and stakeholders about what collective action in sustainable energy means, how it secured its place in the energy system through strategic management, but also how it continues to grow as a movement across Europe and the world. A range of lessons and key insights from relevant case studies and good practices are presented that illustrate how collective action takes various shapes in local contexts and how it develops to inclusive and accessible communities.

The report is outlined as follows: Following the introduction, **Chapter two** begins with putting community energy into the wider context of social innovation in the energy transition, since it can be considered a key manifestation of this concept. It provides definitions and clarifies terms of collective citizen action as well as its place of attachment throughout history, and in today's practice. The report also sheds light onto the variety of objectives, projects, size and business models community energy entails. More particularly, energy communities are framed as manifestations of social innovation, and therefore two theoretical frameworks are presented that address their role in generating transformative change in energy systems (i.e., as in energy markets). These are: (1) Strategic Niche Management, and (2) Transformative Social Innovation. The chapter further addresses "scaling" energy communities, which refers to increasing membership to achieve a sustainable scale of operation and induce transformative change (i.e., intentionally seeking to radically change institutions and practices on current energy markets and other sectors in society), as well as "scaling-out", which refers to the replication of community energy projects in other contexts (e.g., scaling community energy good practices or business models from one region or country to another).

Chapter three describes the challenges and benefits of collective action as well as their drivers and barriers. Collective action means working together in equal, reciprocal and caring relationships to create a more holistic understanding of local energy transitions. At the same time, every energy community is unique (and not all of them strive to achieve transformative change at the national or even global level), and so are their surroundings that they need to take into account.

In **Chapter four** insights into activities and good practice to community energy are presented. They address actions with regard to network formation, multi-stakeholder management, how to engage the wider community, and build relations to the political system. This chapter also outlines some of the different digital technologies that are available for community energy organisations, and sheds light into digital community platforms, blockchain technology, and peer-to-peer trading.

Last but not least, a framework is presented in **Chapter five** on how development, growing, maturing, and scaling community energy can be assessed, monitored, and evaluated. This framework forms the conceptual basis of the Development Progress Tool. The latter is also introduced in this chapter.

2. Development and scaling of energy communities

2.1. Community energy and citizen energy collectives as social innovation

Community energy – or collective citizen action in sustainable energy transitions - can be understood from a social innovation perspective. It pertains to organisations in which citizens are mobilised and collaborate to bring about sustainable energy transition, either at the local level, or even by changing current socio-technical energy systems and the institutions that go along with them (Hewitt et al., 2018). To address this perspective on community energy, it is necessary to introduce the concept of social innovation (of which community energy initiatives can be considered a key manifestation).

The transition to low carbon energy systems cannot solely rely on technological innovation. It also requires attention to the social dimension of innovation. Social innovation, broadly defined as, "new ideas that work in meeting social goals" (Wolsink, 2012; p.8) or "changes in social relations, involving new ways of doing, organising, framing or knowing" (Haxeltine, 2016) has received increasing scholarly attention, for instance on the concepts of community energy and renewable energy cooperatives (Hewitt et al., 2018) for they use new ways of decision making, in which technological developments go hand in hand with innovative ways of uniting different interests via cooperative decision making (Brummer et al. 2017). Unlike other forms of innovation, social innovation includes the connotation of meeting social goals, i.e., new ideas that work in meeting social goals, like achieving a more equitable, just and empowered society (Martinelli, 2012). More specifically, social innovation can be understood as, "innovative activities and services that are motivated by the goal of meeting a social need, and are predominantly developed and diffused through organisations whose primary purposes are social" (Wolsink, 2012; p. 8).

There are several characteristics that pertain to social innovation, and distinguish it from other types of innovation. From an analytical perspective social innovation is seen as a dynamic, and inter-relational process. Social innovation is consequential and is said to induce social change, inventing new alternatives for social interactions and practices—such as doing, organising, knowing, and framing (and often from a collective perspective) (Avelino et al. 2017). Moreover, social innovation induces reconfiguration of social practices, institutions, and networks in such a way that new modes of practice emerge (Hewitt et al., 2018). And whereas technological and commercial innovations generally have financial and business motives, social innovation is more commonly concerned with the wellbeing of people, communities and society at large (Dawson, 2010), and does not require diffusion through business organisations whose prime interest is making profits (Mulgan and Tucker, 2007). In contrary, social innovation typically deals with collective, societal challenges, and environmental problems like climate change (Avelino et al., 2017), and is countercultural and self-consciously formed (by social groups)

in response to unsustainable regimes (Seyfang and Haxeltine, 2012). Hewitt et al. (2018) even argue that social innovation emphasises the role of civil society in creating new ways of responding – i.e. innovative capacity to act - to crises and opportunities. For this reason, social innovation is receiving increased interests from policymakers having a high potential to address complex issues.

Taking these perspectives into account, social innovation can be understood as having another look at social practices in relation to societal challenges, while targeting improvement of societal wellbeing via engagement of civil society actors (Polman et al., 2017). When placing social innovation in the domain of sustainable energy transitions it can be understood as, "Innovations that are social in their means and contribute to low carbon energy transition, civic empowerment and social goals pertaining to the general wellbeing of communities." (Hoppe and De Vries, 2019; p.4). When reflecting on this definition community energy initiatives can be understood as clear examples. This is because community energy initiatives are social entities consisting of social nodes and ties (e.g. between members and the board of an energy cooperative) empowering citizen action. In doing so they use social strategies and incentives that foster sustainable transition goals like energy efficiency, decreasing energy demand, increased uptake of renewable energy producing technologies, increasing the share of renewables in the energy mix, while at the same time contributing to achieve social community goals.

2.2. Defining collective citizen action in sustainable energy transitions

Community energy can be understood as a variety of experiences of renewable energy development and provision, characterised by various degrees of public participation in project development (Magnani and Osti, 2016, p. 148). Goals of community energy initiatives are very varied, and include: installing renewable energy plants, energy savings or sobriety, solving energy poverty problems, making entire neighbourhoods or villages energy neutral, reaching energy democracy, and in general, contributing to the wellbeing of local communities. Community energy initiatives engage with low-carbon energy technologies either at the individual household-level (e.g., lighting bulbs, weather-strips, advice on energy-saving measures on appliances, water-use, heating, roof-based solar PV panels, insulation measures), or at the meso-level (collectively owned low-carbon energy installations (Walker and Cass, 2007), or district heating initiatives (Hoppe and Miedema, 2020; Itten, et al., 2020).

Importantly, the projects, activities and operations enacted by a community energy initiative are inevitably locally bound. For instance, in the case of a collective solar PV panel project: the installation requires a specific physical site. The scale of the locality may however vary for community energy initiatives. Community energy initiatives can have the ambition to meet the energy demand of a small village, an urban district in a medium-sized city, or perhaps an entire island. The notion of "spaces of dependence" is

able to capture this scalar variation of the localities. Spaces of dependence involve "those more-or-less localised social relations upon which we depend for the realisation of essential interests and for which there are no substitutes elsewhere. They define place-specific conditions for the material well-being of people and their sense of significance" (Cox and Mair, 1998) (p.2). For community energy initiatives, these localised social relations are crucial to raise funds and participants. Community energy initiatives are locally dependent as their "primary interest is in defending or enhancing the flow of value through a specific locality: the territory that defines a geographically circumscribed context of exchange relations critical to their reproduction" (Cox and Mair, 1988) (p.310). Nonetheless, community energy initiatives display great variety when it comes to their ambitions, ranging from the goal to raise awareness about sustainability to making a tangible plan of generating an entire "energy neutral" (or even "autark") village (Warbroek, et al., 2019).

In other words, community energy initiatives strive to run their operations and realise their projects through their spaces of dependence. For instance, while certain community energy initiatives primarily seek to foster local ownership of their low-carbon energy installation (making the local community a critical part of their space of dependence), other community energy initiatives (via particular financial constructions) may invite actors or citizens outside of the local community to invest in the project (and as such expand their space of dependence). As such, one should not "conflate the project (that is the community low-carbon energy project) itself with the community it is embedded in" (Becker and Kunze, 2014) (p.181). The sole concept of 'community' leaves indistinct the scalar and spatial configurations and politics involved and implies that community low-carbon energy as such involves to a significant degree a collective and inclusive endeavour (Walker, 2011). Here, community energy can be discerned as either "community of place" (i.e., social relationships embedded in a particular geographical context with a high degree of social cohesion) or as "community of interest" (i.e. social relations extend beyond specifically place-based networks, like RECs supplying energy to their members region- or even nationwide) (Bauwens and Devine-Wright, 2018). Our conceptualization of community energy and its inevitable interaction with its spaces of dependence effectively distinguishes a community energy initiative from its locality through which it seeks to realise its ambitions.

2.3. Emergence, organisation, business models, and related values

Whereas community energy goes back to the late 19th century (REScoop.eu, 2014), the rise of the community energy movement is of more recent age. Whereas small-scaled wind, solar and bio-energy collectives were established in the 1970s, community energy predominantly rose after the Millennium change, with decreasing prices for renewable energy generation, and favourable policy regimes taking hold to support adoption of renewable energy generation. In this regard, it was particularly the policy diffusion of feed-in-tariff schemes across EU Member States that had a favourable influence, and

stimulated the establishment and implementation of supportive policies and institutional/governance arrangements in its wake (Oteman et al., 2014; Wierling et al., 2018). These interventions empowered community energy initiatives to establish their organisations, develop strategies, build capacities, and make it possible (e.g., via subsidies, tax exemptions, green funds, and feed-in-tariffs) to run feasible business cases. The findings from a study by Caramizaru and Uihlein (2020), show that countries with a long history of supporting community ownership are better suited for community energy to emerge. Unsurprisingly, community renewable energy initiatives are more prevalent in higher-income Northern European countries and are currently less developed in Central and Eastern Europe.

Whereas community energy comes in different organisational and legal forms (Walker, 2008) the most common and oldest form is the cooperative. The most common legal-organisational form of community energy organisation found across North-Western Europe is renewable energy supplying cooperatives, abbreviated to "REScoops" (REScoop.eu, 2016). The latter can be defined as groups of citizens who organise themselves to collectively take action to foster the use of renewable energy and increase energy efficiency (Ibid.). Cooperatives foster member involvement, democratic decision-making, and enable equal distribution of generated profits (Magnani and Osti, 2016; Hewitt et al., 2018). A cooperative is an autonomous association of voluntarily united persons to meet their common economic, social, and cultural needs and aspirations through a jointly-owned and democratically-controlled enterprise (Alliance, 2016). The legal entity is laid down in private law, and the exact form differs per country. REScoops do not necessarily require the legal statute of a cooperative, but rather distinguish themselves by the ways in which they handle their business (REScoop.eu, 2016).

This particular way of doing business refers to the seven principles that have been outlined by the International Cooperative Alliance (Alliance, 2016): (i) voluntary and open membership; (ii) democratic member control; (iii) economic participation through direct ownership; (iv) autonomy and independence; (v) education, training and information; (vi) cooperation among cooperatives, and; (vii) concern for the local community. This assures that energy cooperatives take a certain set of values into account in terms of vision, mission and operations. Next to the key cooperative model other business models - i.e., as the design or architecture of value creation, delivery, and capture mechanisms (Teece, 2010; Bidmon and Knab, 2014) - are found among energy cooperatives. Some large-sized, professional energy cooperatives, like LochemEnergie in the Netherlands, for example, run energy projects using other legal-organisation forms like a private limited company or a limited liability company.

Next to those values mentioned among the seven cooperative principles - e.g., democratic decision-making, local ownership of assets - attention also goes out to other values like sustainability (not compromising the interests of future generations), energy citizenship (i.e., active public participation of people within energy systems), energy democracy (low-carbon emancipation or ownership of energy systems by the locals; Szulecki, 2018),

or energy justice (justice in energy service provision pertaining to distributive justice, recognition-based justice, and procedural justice; McCauley et al., 2013). In addition, some - but not all energy cooperatives might also pay attention to the values of energy poverty (i.e., households' access to affordable and good-quality energy services; IEA, 2010) and social inclusiveness (i.e., improving the terms on which individuals and groups take part in society - improving the ability, opportunity, and dignity of those disadvantaged on the basis of their identity). Needless to say, there might be conflicts between certain values requiring that tradeoffs be made to handle them.

2.4. Organisational development of energy community initiatives

In recent years energy communities have flourished in a number of European countries, both in overall number and in diversity (Petrovics et al., 2022). Different countries, with different transpositions of the European Clean-Energy Package, adopted new legislation and policy to cope with this development. Many of these measures contribute to influencing conditions that enable energy communities to develop, professionalise and scale. Among these conditions different factors are acknowledged as relevant for their emergence, growth, professionalisation, as well for their geographical diffusion and internal characterization. An overview of enabling factors to the emergence and development of community energy initiatives (Boon and Dieperink, 2014) is presented in Table 1. The framework on enabling factors by Boon and Dieperink has the aim to be useful for both policy makers and energy communities. The former should facilitate the implementation of these factors, engaging with citizens in the explanation of benefits that can derive from these initiatives and provide the tools for knowledge sharing between communities, as well as between communities and experts. From the other perspective, including citizens and allocating fairly the benefits and the ownership of electricity production sources are key aspects, which new energy communities should consider when establishing an emergent initiative. However, once a REC incorporates the aforementioned factors for its emergence, other considerations have to be made to achieve its survival and success (Warbroek, et al., 2019) distinguish other parameters, considering the social performance at the operational level more than the technical and economic one as before. These factors are grouped and presented in Table 2. Warbroek et al. (2019) show that success needs to be incentivized incorporating the three levels simultaneously (i.e., within the REC itself, interaction with the local community, and in relation to the wider governance context). For example, internal accomplishments in the community still implies cohesion with both the local governance and other communities to reach its full deployment. In the early stages, "organisational capacity" (e.g., having project champions, human capital, fund, and time available) and "linkages to intermediaries" as facilitators are acknowledged as key factors. Then, only once this foundation is built through the implementation of these enablers, low-carbon initiatives have the potential to spread. Warbroek, et al. (2019) acknowledge that RECs pursue a range of different approaches underlining the context-dependency of certain factors that are related to 'success'.

Table 1: *Factors positively influencing the emergence and development of local renewable energy organisations (adapted from: Boon and Dieperink, 2014).*

Founding step	Simulating factors
Emergence of an occasion to establish an energy community (REC)	Fluctuating energy prices A high level of environmental awareness within society Dissatisfaction with inconsistent stimulation policies Dissatisfaction with the national government's incompetence to meet environmental targets Wish to become independent from energy corporations Wish to become independent from energy exporting countries Symbolic benefit in terms of a green image Symbolic benefit in terms of enhancement of social cohesion
Local perception of the REC	A high level of social cohesion Availability of external expertise in terms of organisations that allow the transfer of knowledge The absence of local opposition Existence of other similar local renewable energy organisations Expertise of suppliers of renewable energy and technologies Visibility of renewable energy technologie
Local support and and acceptance of the REC	A high level of environmental awareness within society A high level of social cohesion The absence of local opposition Visibility of renewable energy technologies Co-ownership by local residents A non-constraining participation possibility for local residents Equal and fair distribution of potential benefits The support of external parties (both suppliers and other RECs) Possibility to provide feedback on energy consumed and/or generated
Assessment of the applied renewable energy technology	Visibility of renewable energy technologies Reliability in terms of a proven technology Low initial investment costs A short payback period

Table 2: *Overview of factors that contribute to the success of community energy collectives (adapted from: Warbroek et al., 2019).*

Category factors	Items
Factors related to the REC itself	Project champions Human capital Size Availability of time Access to funds Board diversity
Interaction with the local community	Alignment with local values and frames of reference Alignment with the institutional characteristics of the local community Visibility Community involvement Bonding capital Bridging capital
Governance setting and linkage to government	Linkage to government Linkage to intermediaries Supportive governance arrangements

The question can be raised how different approaches can be engaged at an early stage, from context-dependency factors and the founders of the initiative, to shape the future scaling process of models and best practices? Bauwens et al. (2019) consider two organisational missions: The first one is mutual interests with a focus on members. The second one is about the general interest, with a focus on society or target groups. In fact, these two missions reflect choices made at the beginning of initiatives' development, e.g., type of renewable energy sources, position in the energy market, and have a strong influence on the future of the energy community However, considering the aforementioned context-dependency's relevance, the mission's choice is faced with the surrounding reality, which, as defined by the authors, are other cooperatives of the same sector. Comparing the growth of three energy communities, Bauwens et al. (2019) find that targeting mutual interest can enable breadth-scaling: the initiative's growth is in the expansion to an external audience, while enhancing the members' gains. On the other

hand, promoting general interest can lead, in addition to breadth-scaling, to in-depth-scaling, establishing virtuous circles inside the membership, e.g., horizontal diversification of services.

2.5. Scaling community energy – citizen collectives' actions

In the SCCALE 203050 project, the focus is on experimenting with collective citizen energy projects, measuring growth and performance, whilst seeking to understand the conditions under which they can potentially be "scaled" with the ultimate aim of transforming the larger energy system. However, scaling means different things, and there are different ways of scaling. In the context of community energy "scaling up" could refer to changing institutions, for example by changing laws and policies, while "scaling out" refers to impacting greater numbers, for example by replicating or diffusing community energy projects in other regions. "Scaling deep" refers to changing cultural values, beliefs or relationships (e.g., of community energy members) (Moore et al., 2015).

What scaling up, scaling out, and scaling deep have in common is that they are shaped by a range of factors and issues that apply to both the community level and the system/regime level. These include problems like lacking capacity, the need for sustainable business models, and policy or regulatory mismatch. Addressing constraining factors while utilising enabling factors is considered necessary to scale or even "mainstream" community energy in domestic energy markets. In order to gain a sound understanding of the experimentation and scaling strategies of community energy as well as collective citizen energy projects, it is important to further understanding in certain areas. For example, what community energy and collective citizen action entail in terms of innovation, what scaling strategies apply, and how theory can help us to gain further understanding of community energy in bringing about transformative change, and contribute to sustainable energy transitions while doing so?

2.5.1. Theoretical approaches: scaling of community energy as social innovation

The scaling of community energy or collective citizen energy initiatives – or collective citizen action in sustainable energy transitions – can be approached from different theoretical perspectives. In fashion with common, popular ideas, the concept is related to the notion of scaling innovations – mostly meaning the "upscaling" of techno-economic innovation to reach a wider market audience, and mainstream the innovation into common domestic markets. This is to assume that community energy can be rightfully understood as an innovation of some sort. As was stated in the previous section, community energy can be understood as a social innovation, and the question can be raised whether such kind of innovation can be subjected to scaling like a typical technological or techno-economic innovation. In order to get further hold of this, two theoretical approaches are introduced that cope with the emergence, development and potential breakthrough of innovations. First, Strategic Niche Management (SNM; Kemp et

al., 1998) is introduced as a theoretical framework or "policy tool" that focuses on innovations that emerge, are nurtured and tested via societal experiments in protected "niches". Note that in SNM an innovation is of fairly general nature and can refer to both a technological, techno-economic or social innovation. Second, introduce Transformative Social Innovation (TSI; Haxeltine, 2016; Avelino et al., 2017) is used. It concerns a "middle range theory" to social innovation and its interaction with the wider societal environment. Here, there is a more specific focus on social innovation seen as a relational dynamic process in which new social relationships, behaviours or practices serve the goal to alter, change or replace a current set of (hegemonic) institutions and the socio-technical regime they uphold (e.g., to change or replace the key institutions that uphold and maintain a hegemonic centralised fossil fuelled energy supply system). Thirdly, theoretical insights from the business and organisational domain are used and explored on their usefulness to further understanding in the "scaling of community energy initiatives".

2.5.2. Strategic Niche Management (SNM)

SNM focuses on the nurturing, development and eventual accumulation of socio-technical innovation in so-called "niches" (as a venue where innovations emerge, and are subjected to societal experimentation in a shielded environment, protected from regime and market forces). Experimentation with innovations is key to SNM. Community energy initiatives can be seen as innovation that are nurtured in a niche environment as well. More importantly, niches in which community energy evolves are not just "common" niches, but rather "strategic niches" that seek larger scale transformation and could form the stepping stone for a strategy to scale up community energy as a sector (i.e. replacing the incumbent dominant regime; Seyfang and Smith, 2007). In their article on understanding the scaling of community energy niches in Finland, Ruggiero et al. (2014) introduce SNM as follows. Key to SNM is nurturing of innovation that involves three steps. First, there is *shaping of expectations.* This is considered a fundamental step because it provides direction for learning, it attracts attention, and it legitimates niche protection (Schot and Geels, 2008). Expectations will contribute to niche development when they are shared among a great amount of actors and when they are specific. Moreover, expectations are considered more credible when they are substantiated and confirmed via experimentation in projects (Schot and Geels, 2008). In their study, Ruggiero et al. (2014) found that a key failure to scaling pertained to a lack of a shared vision. Second, *Learning* aims at finding solutions for overcoming barriers that prevent an innovation from functioning properly (Mourik and Raven, 2006) and should not just only address the accumulation of facts and data (i.e. "first-order learning"), but should also pay attention to changing in cognitive framing and assumptions (i.e. "second-order learning") (Schot and Geels, 2008). Third, n*etworking* contributes to creating alignment inside a niche and coordinating the actors that can support local projects. Networks are also perceived as successful when they are broad, include regime actors and when there is substantial resource commitment by the members of the network (Raven et al., 2016).

2.5.3. Scaling niche innovations

In SNM "scaling up" is understood as, "moving sustainable practices from experimentation to mainstream" (Van den Bosch and Rotmans, 2008, p. 34). This can be viewed as a process of niche building from local projects to a global niche (Geels and Raven, 2006; Geels and Deuten, 2006). The latter emerges with the accumulation of the former (i.e., local experiments) over time (Geels and Raven, 2006), and develops when local experiments interact, sharing (cognitive) rules (Schot and Geels, 2008). However, this interaction does not happen automatically and requires active promotion by dedicated intermediary agents (Geels and Deuten, 2006).

In this scaling process there is a central role for intermediaries – or intermediary agents. The role of intermediary agents (i.e., persons or organisations) is to encourage networking and knowledge aggregation. They translate outcomes and insights from certain local experimental projects into more generic knowledge, which can be used to frame and coordinate between a larger set of (other) local projects (See Section 2.5.5 for more information on intermediaries)(Geels and Raven, 2006). This is also known as "broadening" (Van den Bosch and Rotmans, 2008) or "accumulation" (Naber et al., 2017) and refers essentially to the idea of repeating a sustainability experiment in new contexts and linking it to other domains. Here, scaling-up is perceived as the process by which practices developed in niches are translated (Smith, 2007) or embedded (Rotmans and Loorbach, 2006) into regime structures and institutions. This is closely related to the concept of *mainstreaming*, in which scaling is perceived as the societal embedding of experiments (Deuten et al., 1997). Ruggiero et al. (2014) found that a key failure to upscaling of community energy experimentation pertained to intermediary organisations to aggregate local experiences into more abstract knowledge (e.g., good practices, tool kits, business models).

Another aspect important to scaling is *niche empowerment* (Smith and Raven, 2012). This process involves activities that allow niche innovation to compete with an incumbent regime. Key to niche empowerment is creating powerful narratives as political devices. Smith and Raven (2012) discern two strategies for niche empowerment: (a) *fit and conform*, and (b) *stretch and transform*. The first seeks to demonstrate that niche innovation can be integrated into existing regime structures and institutions (Raven et al., 2016). The second one is of more controversial nature, and concerns the changing of the "rules of the game" by reforming institutions and setting new norms (Smith and Raven, 2012). In both empowerment strategies narratives are employed as political tools to promote sustainable transition (e.g., community energy) goals, visions and have them adopted in public policy making processes.

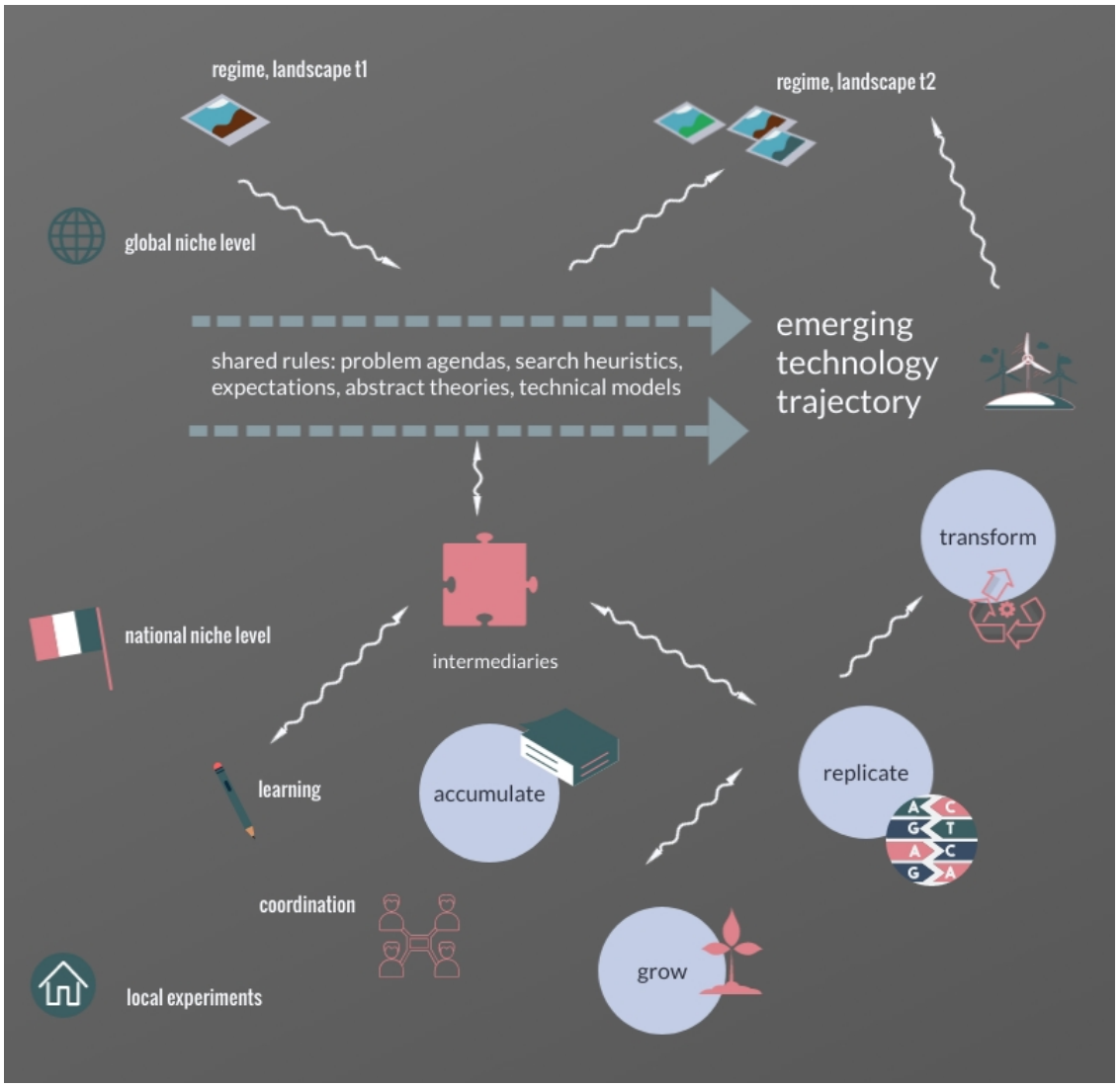
2.5.4. Scaling community energy innovations

Using an SNM research approach Naber et al. (2017) discern four ways of scaling, i.e., growing, replication, accumulation, and transformation, and develop this into a typology. Here, *growing* refers to a dynamic in which an experiment continues and more actors participate in the experiment or market demand increases – the experiment grows in size or activity. *Replication* takes place when the main concept of an experiment is used in other locations. When the experiment is replicated in other geographical locations or contexts, (local) knowledge of the initial experiments can be used in other locations. For example, in 2020 the Belgian City of Bruges adopted "Buurkracht", a citizen collectives' approach developed and already tested in the Netherlands in order to encourage sustainable heating investment by households by using a neighbourhood ambassadors approach. *Accumulation* means that an experiment gets linked to other experiments. In this process, intermediary organisations play a key role in facilitating interaction between experiments that exist simultaneously (Hargreaves et al., 2013). This is important because when the lessons learned in experiments at different locations are compared and aggregated, the experiments can contribute to a more stable technological trajectory at the global niche level (Geels and Deuten, 2006). Finally, there is *transformation*. This does not refer to geographical or physical scaling but refers to the levels in the MLP (Raven et al., 2010). It means that the experiment shapes wider institutional change in the regime selection environment (Smith and Raven, 2012). A graphical depiction of the four scaling types within niche development is presented in Figure 1.

In their study Naber et al. (2017) applied the four types of scaling to a smart grid innovation program (including some with energy cooperatives involved) and analysed different ways in which four experimental projects are scaled. Based on the analysis they find that the building of broad and deep social networks is important for growth and replication; articulating and sharing expectations is important for replication; and that broad and reflexive learning processes are critical to transformation and replication. In another study about scaling of community energy cooperatives (in Belgium, Flanders region) Bauwens et al. (2020) found that the scaling strategies and the orientations toward mutual or general interest of cooperatives are clearly reflected in a set of strategic choices (e.g., type of renewable energy sources and positions in the energy supply chain), which are also influenced by the behaviour of the other cooperatives in the sector. While the focus on members' needs might presume a local, depth-scaling strategy, the study shows how membership may on the contrary be a driver for a breadth-scaling, organisational growth strategy providing economies of scale and scope and thus increasing benefits for the members. This happened in the case of Ecopower, an energy cooperative with a membership base of over 60,000. This tension was eventually resolved by submitting the proposition to become an electricity supplier to the members in the general assembly. Quite surprising, Ecopower members sent a clear signal in favour of starting the electricity supply, while the majority of the board was slightly reluctant to this idea and was willing to keep the focus on localised (small-scale) renewable energy project development. This

spurred a professionalisation process. The findings of the study also show that scaling strategies are not only imprinted by the founding context of each organisation individually, although after its foundation Ecopower quickly started actively looking for regional scaling opportunities (throughout the Flanders region). Scaling strategies also seem to be adjusted according to the behaviours of the other energy cooperatives in the sector and discussed collectively among them (Ibid.).

Figure 1: *Patterns of upscaling and the emerging technological trajectory* (adapted from: Geels and Raven 2006).



2.5.5. The role of intermediaries in scaling community energy projects

Hargreaves et al. (2013) focus on the roles played by intermediary actors in consolidating, growing and diffusing novel innovations (in the case of their study this is community energy initiatives). They define intermediary actors broadly as organisations or individuals engaging in work that involves connecting local projects with one another, with the wider world and, through this, helping to generate a shared institutional infrastructure and to support the development of the niche in question.

Referring to Geels and Deutens's earlier article (2006), intermediary actors are considered to have three roles in niche development. The first role pertains to the "aggregation" of knowledge from across a broad range of local projects. The second role that Geels and Deuten highlight, involves the creation of an "institutional infrastructure" that serves as a repository and forum for the storage, exchange and circulation of this aggregated global knowledge. The third role sees a "reversal" in the relationship and knowledge-flows between local projects and the emerging global niche. Once local experiences and lessons have been sufficiently aggregated to form a shared institutional infrastructure and emerging development trajectory for the niche as a whole, Geels and Deuten suggest that intermediaries then begin to "coordinate" and "frame" subsequent action on-the-ground in local projects: A reversal occurs, in which collective knowledge repertoires at the global level become guiding for local-level activities (Geels and Deuten, 2006, p. 268). In this final role, therefore, intermediaries come to guide the development of local activities by drawing from their aggregated global knowledge to provide advice, guidelines or even templates for how subsequent local projects should be guided and developed.

Intermediaries adopt a variety of methods with the aim to diffuse generic lessons about context-specific projects. Trying to coordinate support for local projects that exist amidst different social and political circumstances is considered challenging (Hargreaves et al., 2013). This is exacerbated by the challenges of building a coherent institutional infrastructure for a sector where aims and approaches diverge, and where underlying resources are uncertain and inconsistent. Despite this issue, intermediary actors seem well-positioned to assist local grassroots innovations address both the intrinsic challenges they face, as well as the diffusion challenges that those looking to expand may encounter. Further still, where local projects do succeed and where they wish to grow and diffuse more widely, intermediaries can potentially play an important role in publicising and building on this success in order to build interest, confidence and momentum in the niche more generally (Ibid.).

A study by Warbroek et al. (2018) builds on the notions by Hargreaves et al. (2013) and adds more insights into the roles intermediary actors have and the strategies they use. They focus on creating conditions in which community energy initiatives can potentially scale: (i) building capacities and (institutional) embedding; (ii) alleviating barriers and lock-ins; and (iii) opening the existing regime for the uptake, acceptance or breakthrough.

For a large part, the diffusion of community energy initiatives hinges on the social acceptance by key actors and markets of the institutional changes and policies that foster distributed generation by communities (Wolsink, 2012). Such acceptance is encouraged inter alia by the prevalence of strong institutional capacity, political commitment, favourable legal and regulatory frameworks, competitiveness of the new technology, mechanisms for information and feedback, and access to financing (Sovacool et al., 2012). Without support and careful coordination for such status quo challenging concepts and configurations, energy communities are not likely to outgrow their niche (Seyfang et al., 2014). Support strategies of intermediaries need to adhere to the issues that vex energy communities. Here intermediaries have a role in assisting building practical and endogenous capacities as well as embedding, helping with alleviating barriers to subsequently open energy and governance systems for new practices and concepts (Ibid.).

Studies on intermediaries show a great variety of actors that may perform intermediary activities. Warbroek et al. (2018) hold that intermediary strategies hinge on two theoretical approaches: endogenous development and asset-based-community development. The key principle of *Endogenous Development* is that development will be more successful and sustainable if it: (i) starts from a base of local resources; and (ii) involves popular participation in the design and implementation of development action (Ray et al., 1999). The endogenous development approach ties people and their innovations, entrepreneurship and capital to the locality. The *Asset-Based Community Development* (ABCD) approach was developed in response to socio-economic problems in US cities in the 1990s. The core axiom of the ABCD approach is to retain a focus on the assets and capacities of the community, instead of its needs, deficiencies and problems in community revitalization efforts (Kretzmann et al., 1996). Consequently, ABCD leaves control with the initiators themselves and instils confidence in communities. Furthermore, ABCD presupposes that the development process is relationship-driven, making use of the social capital present in the community. In their empirical work, Warbroek et al. (2018) discern different roles intermediary agents have:

- Building capacities: Facilitating and Aggregation of Knowledge;
- Alleviating barriers: Brokering;
- Opening up the system for uptake of innovation: Creating institutional infrastructure, Configuring, Framing and coordinating.

2.5.6. Transformative Social Innovation (TSI)

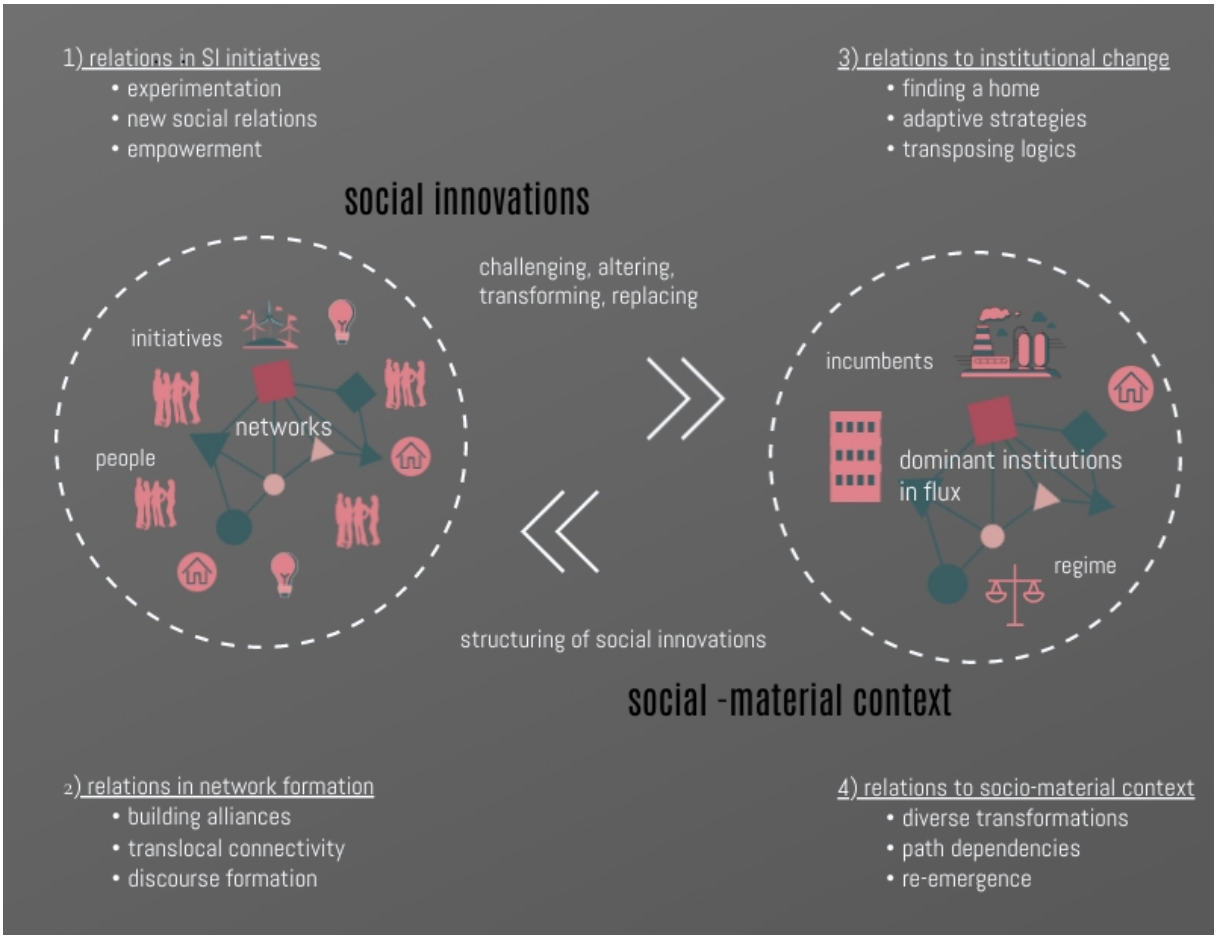
TSI is a middle range theory about social innovation bringing about change in current institutions (Haxeltine et al., 2016). It is of multidisciplinary theoretical nature, and includes origins in SNM (amongst others). TSI is defined as the process of challenging, altering, or replacing the dominance of existing (established and/or dominant) institutions in a

specific social and material context[2], with social innovation pertaining to changes in social relations, involving new ways of doing, organising, framing or knowing. A graphic depiction of the TSI process is presented in Figure 2.

In TSI social innovation initiatives and networks are understood as the key collective actors that instigate TSI processes. Here, TSI-agency applies with TSI agents (e.g. community energy initiatives) having and using their capacities to contribute to transformative change. Of those TSI agents who start having transformative ambitions only a few eventually achieve transformative impact because there are many risks of capture and co-option along the way. In TSI a relational framing is presented as the most suitable way to theorise the emergent nature of social innovation initiatives interacting with changing institutions, where organisational and institutional boundaries are often fluid and under negotiation. In order to have a transformative impact TSI agents need to be empowered, so as to gain a sense of autonomy, meaning, relatedness, increase their skills and competences, and make an impact. Of key importance to TSI agency is having narratives of change – i.e., sets of ideas, concepts, metaphors, discourses or story-lines about (transformative) change and innovation. These are necessary to persuade others (e.g., actors, individuals, organisations, collectives) to share a vision, narrative and join in TSI networks. Here, the sharing of discourse (i.e. narratives) is key to developing actor networks that in turn are necessary to get access to critical resources TSI agents need to increase their TSI agency. In addition, it is noteworthy that several TSI strategies are employed by TSI agents (i.e. including strategic actions) to reach their goal of transformative change in current institutions. Conceptually it can be argued that several forms of "scaling" apply to these TSI strategies. However, in TSI there is no direct mentioning or conceptualization of "scaling". TSI theorists argue that awareness of the complexities and ambiguities of empowerment (Avelino et al. 2017) and of TSI paradoxes (Stirling, 2016) marks an approach to TSI praxis that breaks with the instrumentalism that often prevails in the field. In TSI notions of 'upscaling' and "acceleration" (like in SNM or Transition Management) are considered inappropriate, unreflexive teleologies (e.g. Gorissen et al. 2018). Scaling some sort of a-political technological innovation is different from scaling a fairly politicised social innovation like community energy initiatives who seek to change energy systems confronting political actors having an interest in maintaining the status quo (and hence their interests in the current dominant energy system).

[2] Social-material context: a set of relevant contextual factors that includes institutions, resources and practices; and processes of structuration that result in varying degrees of institutionalisation.

Figure 2: *Graphical depiction of the Transformative Social Innovation process. Adapted from: Haxeltine et al. (2016).*



There are twelve propositions to TSI (Haxeltine, 2017), with a number of them resonating conceptual relevance to the notion of scaling community energy initiatives:

1. Social innovation initiatives provide spaces in which new or alternative values can be promoted and aligned with new knowledge and practices—in a process of reflexive experimentation that supports both members´ motivations and moves towards collective "success" and "impact".
2. Manifesting new/alternative interpersonal relations is one pivotal way in which SI actors are able to create the right conditions to challenge, alter, or replace dominant institutions.

3. People are empowered to persist in their efforts towards institutional change, to the extent that basic needs for relatedness, autonomy, and competence are satisfied, while at the same time experiencing an increased sense of impact, meaning, and resilience.
4. The transformative impacts of SI initiatives depend greatly on the changing tensions within and stability of the action field(s) that they operate in.
5. Transnational networks are crucially empowering local SI initiatives.
6. Discourse formation and its mediation through communication infrastructures crucially enhances the reach of SI network formation.
7. SI initiatives need to find an institutional home in order to access vital resources; this often entails a balancing against the desire for independence from (critiqued) dominant institutions.
8. SI initiatives employ a diverse range of strategies for bringing about institutional change; they must proactively adapt these strategies in response to changing circumstances, while navigating contestations with dominant institutions, and maintaining their original vision.
9. One way in which SI initiatives engage with dominant institutions is by reconsidering the broader institutional logics in which those institutions are embedded; they do this by "traveling" across different institutional logics, and by reinventing, recombining and transposing specific elements.
10. The rise of SI initiatives and the particular transformative ambitions conveyed by them are strongly shaped by the historical development of the wider sociomaterial context.
11. SI initiatives are only innovative against the background of an evolving sociomaterial context. Activities of innovating and invention present but one historical appearance of TSI, next to other less conspicuously innovative activities of re-invention, advocacy, and contextual adoption.
12. Diversity is an integral element of TSI processes, reflecting the historical diversity of the people involved in them, who strive for diverse institutional forms that fit with their differing values, future visions, and present circumstances.

From these propositions several include notions that can be considered relevant to scaling in other theoretical branches, in particular SNM. In proposition 1, "a process of reflexive experimentation" is addressed supporting members' motivations and moving toward impact". This necessitates experimentation (like in SNM) and shows moderate comparison to "deep scaling". Proposition 3 mentions the importance of empowering communities to persist in their effort to institutional change. This highlights the importance of empowerment, a phenomenon that is also found in recent literature about scaling of community energy. Proposition 5 highlights the importance of networking, more particularly via transnational networks. This thesis is also found in research using other theoretical approaches (e.g., SNM; Naber et al., 2017). Proposition 6 is closely connected to proposition 5 as forming discourse coalitions and networks is theorised to contribute to network formation, and more particularly applying prior to the resource mobilising

function of networks. Proposition 7 – finding an institutional home – also fits well conceptually to scaling, although it is not explicitly addressed in SNM or the other theoretical frameworks and literatures that were reviewed under the present study. Proposition 8 addresses TSI agents adapting their strategies in response to changing circumstances was empirically verified with the Ecopower case (Bauwens et al., 2020) in which the members of an energy cooperative during its General Assembly take a more market oriented business model approach deviating from the more traditional localist, egalitarian approach that cooperatives typically use. Finally, proposition 12 looks relevant to scaling strategies because it stresses the importance of diversity (in values, visions, background of actors involved), striving to reach and reform a diversity of institutions.

2.5.7. Overview of scaling strategies, enabling factors and related theoretical concepts

Petrovics et al. (2022) conducted a literature study to identify conditions under which energy communities scale. They discerned 23 separate conditions and clustered them into three categories of scaling; i.e., within (energy community organisations), between (energy community organisations), and in the (external) context of energy communities. First, conditions related to scaling *within* energy communities pertain to items like effective communication, the use of simple rules and procedures, ease of engaging residents, having space to experiment, having a common vision and goals, capacity to mobilise resources, leadership, and sense of ownership. Second, conditions related to scaling *between* energy communities pertain to items like external interaction, presence of intermediaries, learning from other energy communities, network formation, and transferring knowledge and best practice. Third, conditions related to the *context* of energy communities pertain to items like having frameworks or schemes that empower entrepreneur-led experimentation, support for local innovation, supportive financial frameworks or schemes, innovation policy, reliable technology and policy. In addition, Petrovics et al. (2022) discern a few other conditions that support growing and scaling of energy communities like formalising the organisation, matching expectations with (external) stakeholders, the use of participatory processes, and democratised distribution of knowledge.

In light of the previously described factors and theoretical frameworks in this chapter, the study by Petrovics et al. (2022) confirms a large proportion contributing to the emergence, growth, maturation and scaling of RECs. Based on the overview of factors described in the current and previous sections an overview of scaling strategies and enabling factors applicable to RECs is presented in Table 3.

Table 3: *Overview of scaling strategies and related theoretical concepts.*

Category factors	Items
Accumulation	Linking an experiment to other experiments. In this process, intermediary organisations play a key role in facilitating interaction between experiments that exist simultaneously (Hargreaves et al., 2013). This is important because when the lessons learned in experiments at different locations are compared and aggregated, the experiments can contribute to a more stable technological trajectory at the global niche level (Geels and Deuten, 2006; Naber et al., 2017).
Asset-based community development	Retain a focus on the assets and capacities of the community, instead of its needs, deficiencies and problems in community revitalization efforts (Kretzmann et al., 1996), while leaving control with the initiators themselves and instilling confidence in communities. Furthermore, asset-based community development presupposes that the development process is relationship-driven, making use of the social capital present in the community. Furthermore the approach assumes that development processes are relationship-driven, making use of the social capital present in the (local) community (Warbroek et al., 2018).
(Regime) Disempowerment	Refers to the opposite of empowerment. I.e., the process by which actors lose access to resources, capacity to act, and willingness. In theory, typically regime incumbents are normatively expected to be "disempowered" if social innovation agency is to change existing institutions (Avelino et al., 2017).
(Niche) Empowerment	A process that involves activities that allow niche innovation to compete with an incumbent regime. Key to niche empowerment is creating powerful narratives as political devices. There are two main strategies adopted by key niche actors for niche empowerment: (a) *fit and conform*, and (b) *stretch and transform* (Smith and Raven, 2012). The first aims to demonstrate that niche innovation can be well integrated into the existing regime structures and institutions (Raven et al., 2016). The second is more controversial and tries to change the "rules of the game" seeking to reform institutions and setting new norms (Smith and Raven, 2012). The opposite of empowerment is disempowerment. Avelino et al. (2019) define empowerment as the process through which actors gain the capacity to mobilise resources to achieve a goal, which includes actors gaining (1) access to resources and (2) the capacity and willingness to mobilise resources to achieve their goal.
Endogenous development	This approach to scaling ties people and their innovations, entrepreneurship and capital to the locality (Warbroek et al., 2018).

Growing	Refers to a dynamic in which an experiment continues and more actors participate in the experiment or market demand increases – the experiment grows in size or activity (Naber et al., 2017).
Hybrid institutional arrangements	Mainstreaming requires hybrid institutional arrangements and their capacity to safeguard particular transformative ideals and normative commitments. The mainstreaming process is shaped taking a pluralist perspective along the different institutional logics of market, state and community, and the hybrid institutional arrangements that occur in between them (Wittmayer et al., 2021).
Intermediaries and intermediary actors	Organisations or individuals engaging in work that involves connecting local projects with one another, with the wider world and helping to generate a shared institutional infrastructure and to support the development of the niche in question. They translate lessons from local experiments into more generic knowledge and use it to frame and coordinate local projects (Geels and Raven, 2006). More generally, they seek to consolidate, grow and diffuse innovations (Hargreaves et al., 2013). Intermediary actors also have the aim to creating conditions in which community energy initiatives can potentially scale: (i) building capacities and (institutional) embedding; (ii) alleviating barriers and lock-ins; and (iii) opening the existing regime for the uptake, acceptance or breakthrough (Warbroek et al., 2018).
Learning	The process that aims at finding solutions for overcoming barriers that prevent an innovation from functioning properly (Mourik and Raven, 2006). This assumes conducting reflective experimentation. It should not just be limited to the accumulation of facts and data (i.e. first-order learning), but should also stimulate a change in cognitive framing and assumptions (second-order learning) (Schot and Geels, 2008).
Mainstreaming	Here, scaling-up is perceived as the societal embedding of experiments in markets or institutional settings (Deuten et al., 1997; Wittmayer et al., 2020). Mainstreaming uses hybrid institutional arrangements and their capacity to safeguard particular transformative ideals and normative commitments (Ibid.). Mainstreaming and institutionalisation tend to be conflict-ridden processes, rather than straightforward trajectories or integral institutional designs (Lowndes and Roberts, 2013).
Mainstreaming (community logic)	Processes of normalisation and integration with shared values, also referred to as socialisation or "communalisation" (Wittmayer et al., 2020).

Mainstreaming (market logic)	Marketisation and commodification. An important mechanism is the development of new business models, such as energy market places that act as intermediary between producers and consumers (Sandoval and Grijalva, 2015) or reinventing familiar ones, such as energy cooperatives (Capell and Perez et al., 2018). Changes in the energy market include the *redefinition of roles in supply systems* and which actors can take these on (Wittmayer et al., 2020).
Mainstreaming (state logic)	Bureaucratisation and standardisation. Moreover, mainstreaming involves becoming recognised and integrated in state policies (i.e. via subsidies, regulatory challenges, taxation, policy frameworks, but also coping with administrative burdens). When looking at the *actor roles in the state, logic* mainstreaming also includes accommodating steps towards decarbonisation and decentralisation (Wittmayer et al., 2020).
Networking	Contributes to create alignment inside a niche and coordinate the actors that can support local projects. It is considered to be most effective when networks are broad, include regime actors and there is substantial resource commitment by its members (Raven et al., 2016).
Scaling-Across	Replication, diffusion by other actors, and adoption rather than organisational control.
Scaling-Deep	A scaling approach that focuses on improving and enriching current processes in order to enhance the impact on beneficiaries (André and Pache, 2016, p. 665). Depth-scaling modes appear more local and community oriented than breadth-scaling models which are considered more global and client and business oriented (Kannothra et al., 2018).
Scaling-Out	Replicating a (social) experiment or practice in another context. (André and Pache, 2016).

Scaling-Up / Broadening	Moving sustainable practices from experimentation to mainstream (Van den Bosch and Rotmans, 2008) by repeating an (sustainability) experiment in new contexts and linking it to other domains. Some authors understand this as the process of niche building from local projects to a global niche (Geels and Raven, 2006; Geels and Deuten, 2006). To translate lessons from local experiments into more generic knowledge and use it to frame and coordinate local projects. This refers essentially to the idea of repeating an experiment in new contexts and linking it to other domains. According to other authors, scaling-up is the process by which (sustainable) practices developed in niches are translated (Smith, 2007) or embedded (Rotmans and Loorbach, 2006) into the regime. In business administration "scaling-up" is more associated with achieving business growth or franchising via organisational control.
Transformation	An experiment shapes wider institutional change in the regime selection environment (Smith and Raven, 2012).
Transformative Social Innovation	The transformative process of challenging, altering, or replacing the dominance of existing (established and/or dominant) institutions in a specific social and material context, with social innovation pertaining to changes in social relations, involving new ways of doing, organising, framing or knowing. In TSI social innovation initiatives (i.e. like community energy initiatives) and networks are understood as the key collective actors that instigate TSI processes (Hargreaves et al., 2016/7).

Translocal networks	Networking as a way for replicating local innovations to diverse contexts, but also a matter of (1) distributing access to resources and institutions, (2) up-scaling, normalising and institutionalising social innovations and (3) psychologically empowering actors through an increased willingness and belief that they can and want to mobilise resources to realise alternative goals. For example, local and international gatherings, both locally and internationally, are organised for social entrepreneurs to learn and develop competences. Translocal mechanisms of expanding include: • Relatedness: Meeting and relating to others in other places. • Autonomy: Creating larger supportive contexts for autonomous action – e.g. by pooling resources and creating alternative markets. • Competence: Developing and sharing translocal skills and expertise, through becoming part of a larger movement and developing strategies for wider transformation • Impact: Increasing access to resources and legitimacy, based on evidence that there is local and global impact • Meaning: Confirming the broader existence of certain shared values (e.g., shared narratives). • Resilience: Sharing and learning from each other's failures and challenges; drawing on the resources of a larger movement A study by Avelino et al. (2017) found that it is this particular combination of "local deepening" and "translocal expansion" that is specifically empowering.

2.6. Critical barriers and risks

During their lifespan community energy collectives encounter a lot of barriers, with regard to both operational actions and to strategy. This relates to many community energy initiatives being volunteer organisations but also experiencing institutional mismatch and resistance by energy sector incumbents to gain a foothold in energy markets. The first problem relates to issues like volunteer fatigue, austerity, the departure of important persons, changes in policy and the turnover of volunteers. Leadership and volunteering can be disrupted by health issues, retirement and other unforeseen circumstances concerning a core group of key persons in the organisation that are of crucial importance to the management and operation of REScoops. Moreover, alternates are not always easy to find. The limited growth of dedicated volunteers and the loss of key promoters are factors that are known to halt initiatives (Rydin and Turcu, 2019). For reasons of local embeddedness and relying on volunteers community energy collectives also struggle to

collectively organise themselves, and bundle resources and capacities, which leaves them at a disadvantage when interacting or negotiating with energy sector regime incumbents and governmental organisations. Additionally, the extent of professionalisation - experiencing a shortage of technical knowledge and expertise - and the collective image of community energy (as small-sized or petty) negatively affects its development (Proka et al., 2018). Another related problem is lack of social legitimacy because community energy collectives are perceived to primarily be driven by a homogenous group of middle class citizens. Benefits obtained predominantly trickle down to this target group excluding other groups in society (Rommel et al., 2018). A critical value-oriented and political question can be raised whether community energy actually advocates inclusive and just energy transitions, and if not, whether it is able to change course, and how it can use its agency to contribute to this?

Most other problems community energy collectives encounter relate to institutional mismatch and incumbency. Incumbents dominate the existing playing field, which favours corporate ownership and centralised, large-scale energy generation, supply and distribution over decentralised pathways, in which incumbents seek to optimise existing systems through incremental change, which leads to negative externalities like "carbon lock-in" (Unruh, 2000), and impedes the development of grassroots energy initiatives (Hewitt et al., 2019). To protect their interests, incumbents have developed defensive mechanisms to protect against potential market intruders (e.g., via co-optation, developing regulatory frameworks that reinforce locked-in technologies and the interests and institutions that go along with them). Persistent institutional and policy frameworks make it difficult for community energy initiatives to enter energy markets (Bergman et al., 2010). This is also related to institutional lock-in, which inhibits system innovation that allows for the diffusion of low-carbon energy and distributed generation technology (Wolsink, 2012).

This discrepancy between energy market institutions and community energy practices gives rise to a number of problems, like: (a) difficulties associated with obtaining a connection to the grid (Blanchet, 2015); (b) competing with large-scale supply companies that dominate the energy market and have lobby strength (Kooij et al., 2018); (c) encountering and having to comply with outdated energy regulations and legislation (Magnani and Osti, 2016); (d) not having access to sufficient funds to get projects financed (Ruggiero et al., 2015; Hall et al., 2016). Several problems community collectives encounter are related to mismatch with existing institutions. These include: (e) unsuitable spatial planning regimes (Strachan et al., 2015); unstable and uncertain policy frameworks (Ruggiero et al., 2014); (f) limited political support and access to policymaking arenas (Oteman et al., 2014); and (g) experiencing a strained relationship with government bodies not eager to support and empower community energy initiatives (Hufen and Koppenjan, 2015).

3. Preconditions for collective action at the neighbourhood level

Multiple conditions influence how collective citizens actions are able to grow, both on a contextual level and community level, and it is therefore relevant to address them. Since preconditions have complex socio-technical implications (Koirala, et al., 2016), multiple factors are considered in the following analysis: social factors, financial factors, political factors, technical factors and learning factors.

3.1. Contextual preconditions for collective citizen action

Preconditions for collective citizen actions and, more specifically, for local energy communities, are still in the exploratory phase. However, different trends have been already extrapolated and studied, in order to achieve a better comprehension when collective citizen actions succeed or fail.

To support the analysis of preconditions, a schemed view of the energy communities' system is utilised according to Sarfarazi et al. (2020), where the external environment, actor-network and physical system are considered the layers of the latter system.

Relevant external preconditions are government participation in supporting energy communities and regulations, as well as administrative practices that support the status of an energy community (EU, 2019). Government participation is possible in different ways. Verkade (2019) identified available fundings and subsidies, which can vary according to national policies. Furthermore, granting permits and agreements to communities on sections of municipal land and/or rooftops. If the municipality communicates about those community projects in their networks, is additionally beneficial to community energy.

Regarding actor-networks, Ghorbani, et al. (2020) discern three main drivers to participate in energy communities: environmental concern, trust and social norms (Kalkbrenner and Roosen, 2016). Personal gain is also important, entailing not only economic behaviours such as profits and savings, but also social ones which derive from actively participating in a communitarian identity. According to this, Dóci and Vasileiadou (2015) underline that the main enablers for energy community projects are gains (e.g., lower energy costs) and normative reasons (e.g., environmental safety).

A precondition that can make a difference in the long-term is the leadership role, which can be considered both as an intermediary between the government and local communities and as a part of the board of the latter (Forrest, 2014; Hoppe et al., 2015; Ghorbani et al., 2020;).

On the physical layer, Verkade (2019) identified three practices, promoting, developing generation and developing management, where the relevance of the technology choice is highlighted, as well as the type of storage and energy monitoring systems. As underlined in the Community Energy Guide by REScoop.eu (2020), multiple choices are available,

wind, solar, hydro and biomass sources, and finding the technology (or technologies, in large-scale projects) which fits restrictions and acceptability is an important context-dependent decision.

In conclusion, contextual preconditions are multiple and diverse, and thus makes it difficult to establish an unique framework that enables the extrapolation of drivers and barriers for energy communities. However, the attempt of this literature review is to provide insights from available research on collective action supporting citizen-led energy initiatives on decentralised energy transitions.

3.2. Enabling conditions and empowerment

To achieve an understanding of how diverse characteristics of collective citizen actions can enhance (or disincentive) its success, this section focuses on the members of the community, the internal professionalisation, the financial availability, the technologies involved and the relation to the external community as well as the government.

3.2.1. Members of the community: quantity, quality, diversity and commitment

In decentralised energy production systems at the local level, members of the community are actively shaping not only the energy market, but also policy evolution and its regulations (Bauwens et al., 2016). This social factor, which considers quantity, quality, diversity and commitment of communities' members, is regarded as relevant for establishing the success of these systems.

Regarding the quantity, at the European level, no specifics on numbers are made (EU, 2019); however, the implementation can be different from one country to another, e.g., in Greece a minimum number of people is specified (Frieden et al., 2020). In any case, REScoop.eu (2020) suggests to "start small, grow big". The first period of establishing energy communities is characterised by the necessity to develop trust between members and to establish leadership roles which are going to be the foundation of the projects' growth (Forrest, 2014). More in detail, the leadership role is acknowledged as valuable from the beginning, when it is time to search for investments and permits, to the development phase, which implies scaling the community and including more participants (Martiskainen, 2017). In fact, once the project starts, it gets easier to recruit new members showing extensively the benefits and the low risks implied in joining a community (REScoop.eu, 2020). Similarly, with the development of the renewable energy projects, the size of the community increases,, and with it inevitably the diversity, the available skills and networks of its members (REScoop.eu). Moreover, increased contribution can also occur in the shape of financial and/or physical investments (Gui, 2018). In addition, since projects during the first years are supported mainly by volunteer work, having a diverse community can nurture the needed knowledge, in order to achieve successes in their deployment (Capellan-Perez, 2018). Hence, as underlined by Blumer et al. (2013), not only the number but also the commitment has a relevant role in the success of energy communities' projects.

3.2.2. Internal professionalisation: identifying and training key personnel

The first barriers that local energy collectives encounter are scarcity of time, of financial support and expertise (Brummer, 2018). Even though REScoop.eu (2020) suggests the building up of a core team, this is not easy to implement in practice. Skills are required, since those are the main source of knowledge, at least at the beginning of the project, on which it can be relied upon. Subsequently, with the growth of the project, new levels of professionalisation are needed (Capellan-Perez, 2018). Hence, according to Brummer (2018) and Herbes et al. (2017), identifying and training personnel is key for scaling.

3.2.3. Availability of finance

Lack of funds and of profitability, as well as risk aversion, are few of the barriers that a developing energy community has to face (Herbes et al., 2017). Thus, after the deployment of feed-in-tariffs (FiT) and likewise after their abolishment , the necessity of new business models arises. As underlined by Herbes et al. (2017), communities, different from profit organisations, address the concept of "value" from another perspective, mainly based on the Return-On-Investment (ROI) of dividend payments. Fioriti et al. (2021) add the Net Present Value (NPV) and the Capex/Opex of the project as measures for investments and fundings. In addition, the authors mention that a key value of an energy community should be the prosumers' welfare which arises from offering lower energy prices, welfare appointed as "ideological surplus value". Thus, not only the economic gain is relevant, but also the psychological one, an aspect strictly linked with the public acceptance of energy communities. Hence, new business models should consider those aspects, while including the democratic process of voting for decisions.

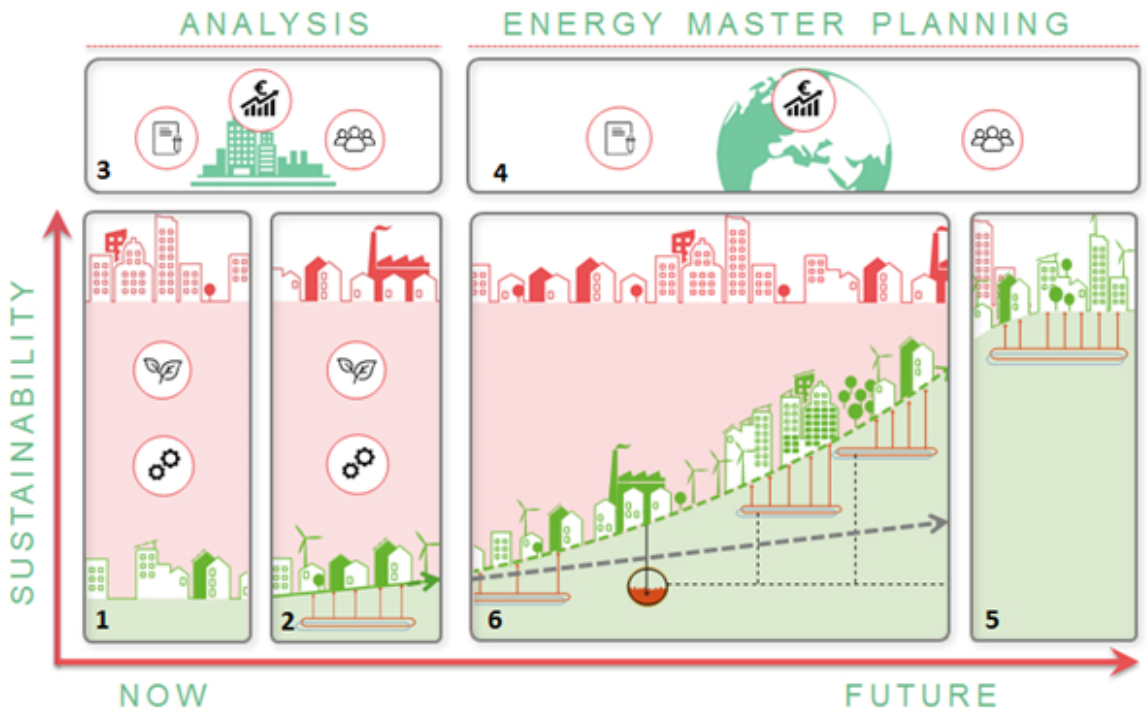
Studies on new business models for energy communities, (e.g., Brown, 2019; Fioriti et al., 2021; Nolden et al., 2020) highlight the necessity of having an intermediary present, even more so when FITs are being revoked all around Europe as a form of subsidy. The intermediaries should have the role of facilitators in stakeholders' participation and in aligning with policy changes. They can also be investors of new projects, certainly when revenues of the energy community are high enough. Furthermore, Herbes et al. (2017) identify a number necessary elements for the growth of a community through the implementation of new business models: merging with other communities, implementing cooperation with external institutions and stakeholders as well as employing a professional management team. Last but not least, without the support of local and national authorities and feasible legal frameworks their process of development will result in stagnation.

3.2.4. The role of technology

At the technical basis of an energy community is the ability to satisfy an existing or future energy demand throughout the year, by means of a (renewables based) energy source. Although the type of demand (heat, cold, electricity) narrows the available options, the choice of systems and scales is still vast, and technical systems design frequently requires experts. Lately, more accessible information on how renewable energy technologies

operate is increasingly available, making it possible for citizens, policy makers and others to better access the conversation and make high level choices. An example is the "Catalogue of Measures" developed in the City-zen project[3] (Broersma and Blom, 2018), which provides two page overviews of a vast array of renewable energy technologies and concepts.

Figure 3: *The City-zen energy transformation methodology (Dobbelsteen et al., 2019, p. 11).*



The City-zen project additionally developed a methodology (Dobbelsteen et al., 2019) that results in a roadmap towards the goals set for a local renewable energy system. The methodology can be summarised in six steps, divided in an *analysis* section and an *energy master planning* section, as illustrated in Figure 3:

ANALYSIS

1. Basic energy analysis;
2. Present planning and trends;
3. Stakeholder analysis;

[3] http://www.cityzen-smartcity.eu/

4. Scenario for the future;
5. Energy vision;
6. Roadmap.

In the analysis part the current technological, planning and stakeholder landscape is mapped, in the subsequent energy master planning part, future trends, the desired vision (with goals that realistically fit available potentials) and the roadmap towards that vision are shaped.

Although this methodology was developed towards municipalities, the basic principles are useful for energy communities as well. Analysis helps to develop a better sense of what is and what isn't possible, and supports developing a vision and roadmap. Even if these are relatively rough in their setup, they will assist in making realistic, no regret-technology choices.

There are still challenges in accessibility of the underlying (open) data when assessing available residual and renewable energy potentials (Fremouw et al., 2020), however the route towards making a technology choice is becoming more accessible to individual citizens, and therefore energy cooperatives. Examples of energy potential mapping (Dobbelsteen et al. in: Droege, 2018) efforts are the *Nationale Energieatlas*[4] (National Energy Atlas in English) in the Netherlands and the *Hernieuwe Energieatlas*[5] (Renewable Energy Atlas in English) in Flanders, Belgium, which have combined a large number of high resolution energy transition datasets in a web map viewer, allowing anyone to zoom in on their area of interest to determine for example geothermal potential, solar potential on roofs and aquifer thermal energy storage (ATES) potential. In time, the EU INSPIRE portal ("Infrastructure for Spatial Information in the European Community") will disclose this and similar datasets across the European continent[6].

3.2.5. Energy efficiency and savings

Community energy collectives are increasingly considered important players in renewable energy and energy-saving efforts, in terms of raising awareness locally and gaining public support for low-carbon energy and energy savings projects (Coenen et al., 2017). Next to generating renewable energy community energy collectives are involved in energy savings (See for example the Horizon 2020 "REScoop Plus" project). Because of their embeddedness in local communities they are considered to be well positioned to reach out to and approach local community members in energy saving actions. Energy saving

[4] https://www.nationaleenergieatlas.nl/
[5] https://www.geopunt.be/ (select 'energie' and 'Hernieuwbare Energieatlas Vlaanderen')
[6] https://inspire-geoportal.ec.europa.eu/overview.html?view=themeOverviewandtheme=er

actions can be achieved in two ways: by using energy more efficiently or by reducing energy demand. Behaviours related to energy conservation (including those with the aim to save energy) can be categorised into curtailment behaviour and efficiency behaviour. The former concerns ongoing day-to-day actions, such as setting thermostats or switching off lights. Efficiency behaviour on the other hand concerns one-time actions to save energy, such as investing in home improvements like thermal insulation or installing energy-efficient appliances (Frederiks et al., 2015).

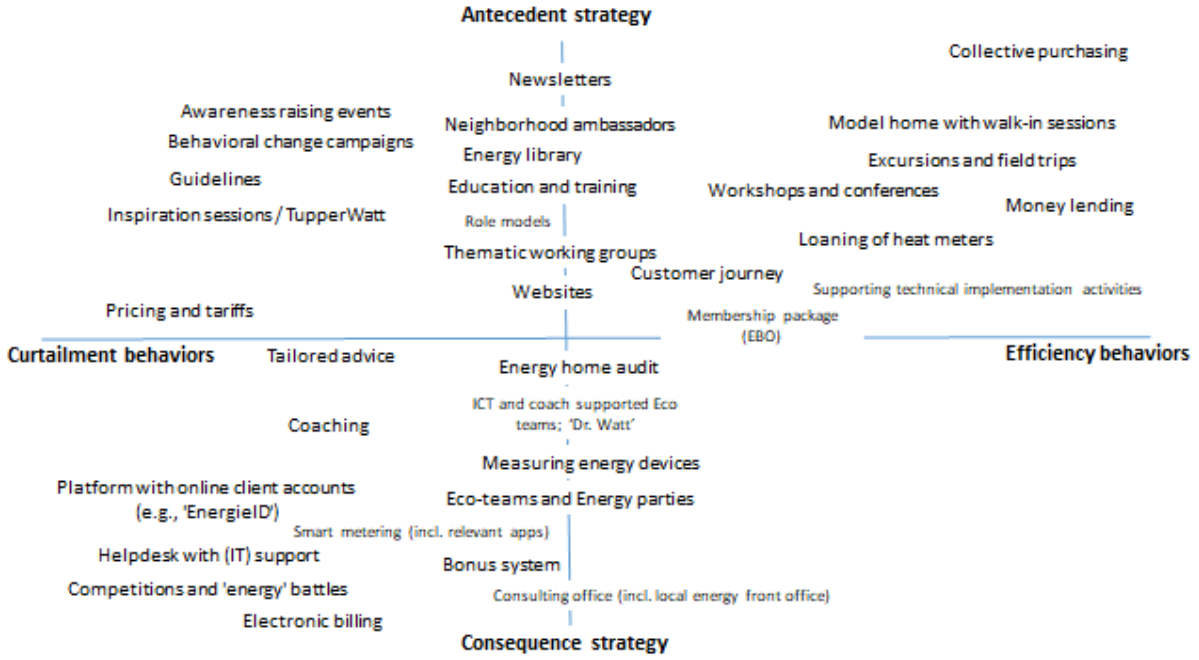
The New Stepped Strategy (NSS) (Dobbelsteen, 2008) specifies three steps towards a fully (energy) circular building, starting with reducing demand, followed by reusing waste flows and finally generating only the remaining amount required using renewable sources (as well as releasing only clean and nutritious waste to the outside world). For buildings, the first step practically means applying shell insulation (walls, windows, roofs and the lowest floor). The second step involves using heat exchangers (for example on the ventilation exhaust and the shower drain) that reclaim a large amount of the heat which would normally be lost to the environment.

Because the first steps involve increasing efficiency and savings, and (internally) reusing waste flows, the remaining energy demand will be smaller than original, therefore allowing a smaller system to supply this energy, or conversely, the same size collective energy system to supply to a far larger number of buildings.

For this and other reasons, energy efficiency is promoted by the European Commission in the Energy Efficiency Directive (EED) (EC 2012). As heating and cooling in the built environment accounts for almost 40% of the total final energy demand in the EU (Kavvadias et al., 2019), the EC has established the Energy Performance of Buildings Directive (EPBD) (EC 2018). This has resulted in many EU member states establishing Energy Performance Certificate registers (EPC, practically referred to as *energy labels*). Energy labels provide insight in the energy performance of the building stock, and can therefore also be used in assessing realistic improvement goals. Although these range from A to G, upgrading a building from the worst category (G) to the best (A) may not provide a return on investment in a realistic timeframe (Menkveld et al., 2020). Therefore it is more cost efficient to limit improvements to the building shell to a smaller number of "label upgrades" (in Dutch: "labelsprongen"). For example from labels F-G to C, and from labels D-E to B. Which end label is desired may also be tied to the desired temperature level of the heating system. Buildings with better energy labels are more easily adapted to low temperature (LT) heating systems[7], because the energy lost per square metre of building shell in winter will not outpace the amount of energy that floor and wall heating can provide.

[7] https://ltready.info/

Figure 4: *Overview of actions community energy collectives undertake to encourage home energy savings (Hoppe and Coenen, 2021)*



As can be observed in Figure 4 there is a wide range of measures energy collectives use. The figure reveals that the majority of measures uses antecedent strategy (i.e. strategies trying to influence one or more behavioural determinants prior to some kind of energy-saving behaviour) rather than consequence strategy (i.e., trying to influence behavioural determinants after the occurrence of the energy-saving behaviour; e.g., by providing feedback) and that curtailment behaviour appears to be targeted more than efficiency behaviour. The majority of measures can be seen as capacity tools with the aim of informing target groups about the benefits of energy savings and to prepare energy communities how to engage in energy saving behaviours. Examples include the use of energy ambassadors, awareness raising events, inspiration sessions and using mock homes including state of the art energy efficient technology as a role model. Incentive tools (like rewards or competitions) are also observed but appear less frequent (Hoppe and Coenen, 2021).

3.2.6. External community: from broader society to government and opposition

Communities, in addition to their internal development (members, professionalisation, business models and employed technologies), interact with external stakeholders. In fact, the members of decentralised citizen-led energy initiatives are initially regarded as prosumers, which implies the role of both consuming and producing energy (Parag and

Sovacool, 2016). Thus, new partnerships, as well as new business models and contracts are arising between prosumers and aggregators, or between prosumers and suppliers and between prosumers themselves (Brown et al., 2019).

Furthermore, through joint-fact-finding and citizen sensing, energy communities can collect data that helps them find out more about issues the broader society cares about. In joint-fact-finding, the stakeholders initially work together to agree on parameters, on scopes and scales, before they develop or commission scientific viewpoints. In citizen sensing, people use digital sensors, or record their behaviour, helping them to "make sense" of their everyday life and surroundings. Examples are collecting data on traffic, pollution, energy consumption etc. and to record barriers of change.

However, embedding collective action in sustainable energy into a formal policy-making process can be challenging and needs a good bond to local politics. For example, new collective energy infrastructure might be better installed as part of a broader neighbourhood development project (Itten et al., 2020) and may be co-designed to achieving multiple goals (e.g. installing district heating to lower carbon emission, cut heating costs and at the same time become more resilient to extreme weather events than the previous system was).

In fact, if approaches to include the wider community are neglected, a growing community can face severe local opposition (Herbes et al., 2017). Energy communities, with the help of both intermediaries and local governments, have to work on establishing social cohesion between their members and the broader society (Boon and Dieperink, 2014). An advantage of building social cohesion is not only a fruitful interaction, but also a better understanding of and improved attitude towards renewable energy sources in the neighbourhood or municipality as a whole (Bauwens and Devine-Wright, 2018).

While embedding energy collectives into public policy can bring visibility and growth opportunities to energy collectives, a crucial challenge that has been noted is how they can keep their autonomy (REScoop.eu, 2020). It is suggested that precautionary agreements, or memorandums of understanding are set up about the rights and obligations for all the parties involved, be they citizens, the municipality or other stakeholders.

3.2.7. Policy level: from policy instruments empowering community energy to public participation

Interactions between energy communities and stakeholders, as explored in the previous chapter, are necessary factors that need to be considered when looking at a community's development. This also holds for communities embedded in multiple territorial levels, e.g., the European Union, the national, regional and local governments. All those layers contribute to the success of energy communities.

Between 2018 and 2019, the European Union defined the legal framework for energy communities through the clean energy for all Europeans package, acknowledging

associations, cooperative and other types of communities with legal entities. Firstly, with the revised Renewable Energy Directive (EU) 2018/2001, "Renewable energy communities" (REC) were established; a strict requirement for being entitled as REC is the use of renewable sources in the energy production process (European Parliament and Council of the European Union, 2018). Furthermore, the revised Internal Electricity Market Directive (EU) 2019/944 extended the role of energy communities to all types of electricity, by defining them as "citizen energy communities" (European Commission, 2019).

Nevertheless, energy communities are substantially exposed to national regulations. The transposition of the aforementioned EU directives in national regulations is left to the discretion of the singular country. An in-depth analysis on this topic is conducted by Frieden et al. (2020), where the different implementations are examined country by country. The main takeaways were the inclusion during the transposition procedure of both technical aspects (e.g., grid tariffs, capacity) and governance ones (e.g., role of members and eligibility). However, the latter are noticed not to be enough in supporting the spread of energy communities. Few barriers which are still hindering this process are the lack of support on the administrative level (e.g., fewer transaction costs) and the lack of fundings (Brummer, 2018).

Furthermore, in order to achieve impact policies ought to be implemented considering a holistic and comprehensive view, reflecting the complex social, economic and technical factors which characterise an energy community: "A successful transition to support community energy requires a beneficial mix of policies from different bodies of legislation such as building codes or general planning processes" (Busch, 2021). Adding criteria in tenders such as to include local communities and local ownership of renewable energy projects could not only favour the position of energy communities, it could also to support citizen participation as a whole (Caramizaru and Uihlein, 2020). In addition, Bomberg and McEwen (2012) underline the support on financial aspects from governments, but also on "structural" and "symbolic" resources, e.g., engagement and assistance for decision-making aspects. In fact, facilitating knowledge sharing (Boon and Dieperink, 2014) and a less dependence on voluntary work (Capellan-Perez, 2018) are objectives that are still not considered in national policies.

Therefore, a deep understanding of benefits and resilience of energy communities is key both at the European level and at the national government level (Capellan-Perez, 2018). This can lead to a more proficuous communication and collaboration with local authorities and with citizens (REScoop.eu, 2021).

4. Community energy actions: suggestions and good practices

In nurturing and shielding community energy as a social innovation, it is necessary to pay attention to three processes that help maturing community energy and reach the next step. Taking an Strategic Niche Management (SNM) approach these processes pertain to: (i) voicing and shaping expectations; (ii) social network formation, and (iii) developing a learning environment (Kemp et al., 1998; Raven, 2006; Schot and Geels, 2008). What might additionally help here is creating a protective environment in which community energy collectives can work in a protected environment, like "regulatory sandboxes" or policy experiments or other forms of regulatory exemptions or "holidays".

Additionally, attention in this chapter is paid to activities that are particularly useful to community energy collectives like citizen engagement, multi-stakeholder management, stakeholder involvement, the use of digital tools, crowdsourcing, gamification, lobbying, cybersecurity and data protection.

4.1. Shaping and voicing visions and expectations

Expectations relate to how community energy innovations are presented to the public and whether they live up to the promises they make about their performance and effectiveness. The strategy is to get the benefits of community energy projects on the agenda by making promises and raising expectations about the benefits it offers. Voicing and shaping expectations is considered a good thing if they are specific, credible, and whether they are shared by community energy members and stakeholders with whom they interact (Kemp et al., 1998). Expectations become more robust as a larger variety and number of people or stakeholders share the same. Once certain promises have been accepted and placed on the agenda, activities need to be developed to substantiate the expectations, for example by conducting research or doing experiments. Voicing and shaping of visions and expectations is beneficial for several reasons. First, to articulate a desirable future world and set a long term goal (as a mental guiding, agenda setting tool). Second, as a means to link expectations to important events at the macro scale (i,e., landscape developments) and tensions in current energy markets (i.e., regime tensions) (Ibid.). This can be used to design potential pathways that guide strategic actions or as a monitoring tool to gain insight on how to reach the set goals. And finally, expectations can be used as a means – e.g., as part of a narrative - to attract and persuade people or organisations who can share resources like budget to invest in community energy projects. Sharing useful resources helps in building discourses and networking ties with other organisations (Avelino et al., 2018). Community energy collectives – especially those in the start-up phase - can organise workshops to voice and shape visions, expectations and convincing narratives. In addition, pathways and future scenarios can be developed, for example by using a backcasting approach (Quist and Vergragt, 2006).

4.2. Social network formation

To further develop the organisational environment in which community energy collectives operate there is a need for social network formation because social networks enable the mobilisation of critical resources (like funds, competences, knowledge). Here, a social network is conceptualised as a system of interrelated actors who exchange resources and are mutually interdependent (Wasserman and Faust, 1994). Through interaction in networks, community energy collectives are enabled to exchange information, knowledge and resources. can take place. Different actors bring in different resources that are necessary to make community energy collectives flourish. Moreover, social networks provide a flexible structure that forms the basis for the exchange of ideas and discussion of values between different categories of actors needed to solve problems, and can support collective, reflexive learning and by doing so, contribute to sharing narratives and visions. Networking allows for aligning goals and strategic coordination of actions between the organisations involved. When facilitating learning in networks it makes sense for community energy collectives to connect oneself (or as an entire social network) to platforms (often hosted by intermediary organisations) on which good practices and critical knowledge about the development, business cases, relevant regulatory frameworks, ways to generate funds and technical knowledge are shared. The platform may be used to collect insights from and connect to the local community energy project, but can on the other hand also be used to guide and support the local community energy project in a more strategic way (relying on more knowledge than those only involved in local projects) (Avelino et al., 2018). For community energy, social networking is necessary on the one hand to reach out to the local community and get their support or to mobilise local resources. On the other hand, networking is useful to reach out to critical actors and stakeholders outside the local networks. These are typically professional and government actors who possess access to critical resources, like investment schemes and subsidies to support (business cases of) community energy projects (e.g. in collective renewable energy generation). Connection to intermediary agents in professional networks is also of critical importance, particularly if community energy collectives seek to “broaden” or “scale” their operations (Hargreaves, 2013).

4.3. Facilitating learning

Strategic Niche Management (SNM) is an analytical tool, which depicts the dynamics of expectations, network formation, the learning processes and feedback loops between these within different levels of interactions (Schot and Geels, 2008). The three dimensions are interrelated with each other: all of them have to be used efficiently and coherently in order to achieve a successful deployment of the niche’s innovation. Firstly, expectations define the direction of innovation, its use, design and consumers addressed; networks give the opportunity to the innovation to develop: the higher the quality of the network, the higher the quality of the performance in the deployment of the innovation; then, the

knowhow, learning process and knowledge sharing are necessary for the progresses of the innovation (Kamp and Vanheule, 2015).

According to Schot and Geels (2008) and Hoogma et al. (2002), the learning process for SNM is classified in two orders, gathering data and understanding values and norms. Thus, scoping to energy communities, facilitating learning implies facilitating both the data-retrieving procedure and changes in the socio-technical landscape's vision. Furthermore, Kamp and Vanheule (2015) highlight the necessity of an integrated system of "interactive learning" between different stakeholders as a key aspect for ensuring a learning process and, thus, the scaling of energy communities.

In more detail, Ruggiero et al. (2018) conclude that intermediaries have the role of facilitators in the learning process, e.g., providers of a projects' database, sharing knowledge or organisers of door-to-door events. In their study on energy communities in the UK, Seyfang et al. (2014) stress that in order to become more robust, "a set of intermediary organisations is needed to consolidate and aggregate the learning and experiences of local projects, to repackage them for implementation elsewhere, and to lobby effectively for policy and industry support". Klein and Coffey (2016), acknowledge learning limitations through context and location dependency of energy communities, and portray external intermediaries as a solution.

Furthermore, communities cooperate with one another to increase learning. For example, co-operatives UK or Som Energia in Spain enable the creation of a network between energy citizen-led initiatives, sharing know-how, support to renewables and policy levers (Coop, 2019; SomEnergia, 2021). Overall, the learning process is one factor of a more complex landscape, where network formation and expectations play a role. However, if this factor is lacking, a successful pathway for scaling-up energy communities is challenging.

4.4. Multi-stakeholder management

Multi-stakeholder management is defined as a collaborative, non-hierarchical process, wherein participation is voluntary and where objectives and actions are negotiated among participants (Roloff, 2007). Multi-stakeholder processes emerge when a problem becomes urgent for several different actors, who believe that they must work together to tackle challenges such as the local energy transition or climate action and adaptation. Most multi-stakeholder networks at the local level include residents, representatives from civil society, businesses, and the municipality (Ibid.).

In most cases, multi-stakeholder processes involve the exchange of information, transfer of knowledge and ideas, with the aim to achieve mutual benefits. Instead of competing between organisations and interests, mutual recognition, sharing of responsibility and learning from each other are principles rooted in the multi-stakeholder processes. Actors should simultaneously disseminate their knowledge and incorporate lessons-learned from

others (REScoop.eu, 2020). Knowledge about renewable energy sources, financial and legal models, the ownership and the governance of the projects, community reinvestment, etc. are common examples that are shared between stakeholders.

In most cases, there is also a normative dimension to multi-stakeholder networks, as commitments, norms and principles of the different parties intersect (Sanderink and Nasiritousi, 2020). They might be either contradictory, complementary or confirmative, and will result in early synergies, negotiations or conflict resolution. Conflicting points of views and antagonist relationships are not an uncommon phenomenon at the outset of multi-stakeholder processes and should be embraced early rather than ignored. Otherwise they will surface again at a later stage.

4.4.1. Multi-stakeholder deliberations

Individuals and groups that are bound by a collective action in sustainable energy usually enter multi-stakeholder networks with the attitude that they "know what is right". As Mansbridge (2009) describes, they bring together facts and insights from their various sources of information as well as from past experiences. Subsequently they reflect together on their motivations, interests and preferences, which might not align in the first place. Continuous and trustful deliberations will give them insights into the distinct drivers and barriers of the other stakeholders. In other words, the objective is to understand each other's interests in sustainability, in autonomy, in managing public resources, in economic motives, in developing new technology, or the like. Other questions might address what private or public values the participants adhere to, and if they are short-term or long-term interests. For example, how can energy communities add to collective welfare, such as creating extra recreational spaces; upgrading neglected neighbourhoods; increasing housing comfort; reducing energy poverty; stimulating job creation and the like?

Citizens become involved in collective action for different reasons than for example the municipality or a local energy supplier. It is therefore crucial to discover individual objectives and common benefits in early inquiries. During this early interaction, storytelling by individual citizens are as important as experts' opinions or political statements. As a result of stakeholder deliberations, central and competing interests will be transformed into a shared meaning (Roloff, 2007). Through understanding the others' opinions and interpretations of the problem, the participants grasp the complexity of the issue and learn about interdependencies that were not apparent before. Their self-interests may turn out to be compatible with each other and their opinions on the common good not too far away (Mansbridge, 2009). That being said, collective actions in sustainable energy with diverse stakeholders are not on-off experiences, and must be well prepared and expectations managed.

4.4.2. Stakeholder assessment

Collective actions usually start by a smaller group and tend to include more and more diverse actors during the process. One of the best ways of identifying all relevant stakeholders is through snowballing, by starting to identify key stakeholders within each

partner's own network, especially those that might have important knowledge or authority over a certain domain, or are simply too important to be left out (Itten et al., 2020). Small energy communities for example may have useful contacts and resources, but local authorities can have a bigger reach. The local authority can be very helpful to bring relevant economic, societal, environmental or energy actors, such as energy agencies or distribution system operators to the table (REScoop.eu, 2020).

As soon as the most obvious stakeholders are identified, members of those identified groups can be asked to name additional relevant, affluent or affected groups who should be invited. Most of the time, the initial participants agree to err on the side of inclusiveness. The initial groups might also brainstorm about groups that are not represented, or those who are not able to represent themselves (Susskind and Cruikshank, 2006).

As mentioned earlier, an important stakeholder group to assess are intermediaries. They represent a special group of stakeholders that are important to access knowledge, institutions and increasing outreach. Existing intermediaries include inter alia: government funding agencies for local renewable energy, legal and financial consultants and many existing energy community networks. Intermediaries can support the multi-stakeholder management to formulate a comprehensive community strategy and represent community energy beyond those already involved. They can be especially important when there is a need to mediate between the various community energy visions, to guarantee that scaling community energy is inclusive rather than an orchestrated expansion (Bird and Barnes, 2014).

This points to the fact that a multi-stakeholder dialogue ought to include more than the "usual suspects" (Pape and Lim, 2019) and should succeed at involving groups of stakeholders who differ on average, demographically and socioeconomically. It is not only pertinent to identify and activate less powerful and marginalised groups but also to organise multi-stakeholder processes in such a way these groups are able participate in their everyday life (see next point citizen engagement).

Another important issue is that those stakeholders who represent larger organisations or larger communities have sufficient authority to make commitments on behalf of their members. Without this authority there is the risk that a solution or compromise within the multi-stakeholder process may not reflect the interests of the represented group and could easily be rejected by its members. As noted before, every party, whether private, public, non-governmental or citizen-based comes with a set of constraints born out of its own identity and unripe proposals can fuel antagonist relationships (Itten, 2018).

4.4.3. Expanding citizen engagement

When energy communities try to involve citizens in collective action beyond their core membership group, they can focus on snowballing, and extending to supportive groups or can try to reach the broader public. There are many low and high intensity forms of participation - information, cooperation, consultation and financial participation, all have positive influences. For small and large-scale energy community projects, characteristics

of the participation process such as transparency, inclusiveness and collaboration shape public perceptions of new energy technologies. As Boudet (2019) argues, process-based factors may be more important in shaping attitudes towards sustainable energy systems than the actual distribution of costs and benefits. For example, local residents are inclined to oppose a project when they feel that decision-making serves the economic interests other than their community or when local aspects such as the noise level, the distance from the turbine to the place of residence, the scenic value of the landscape and nature protection are brushed under the carpet.

Independently of the approach chosen, the participants should be an inclusive group as well as a more or less representative sample of the local population (Itten et al., 2020). The sample of the broad community is usually not the 10% most advanced in sustainability or the 10% most reluctant to it, or the 10% who may not care about anything, but members of the 60–65% of the remaining middle group. To activate those middle groups, it is recommended to make first use of existing contacts, resources, and established communication channels within the community energy organisation. Then it is important to know other communities that exist, e.g. are there citizen panels, ambassadors, neighbourhood committees, farmer cooperatives? Are there other project partners or intermediary organisations already involved in local sustainable energy action?

The earlier stakeholder identification process should yield clear information on where the different subgroups of citizen groups can be found; through which channels, platforms, intermediaries or previous contacts they might be best approached. The use of established contact points such as direct mailing, social media, apps, or office branches, are recommended, as is the possibility to co-design a wider communication campaign together with citizens. The use of gamification (see Section 4.5.5) to show the benefits of participation and create higher engagement rates is a further approach that has been proven effective. To make participation effective and meaningful, it is crucial that the wider community that should be involved is studied well, e.g. it should be known beforehand which type and complexity of language they use, which values they regard important in terms of sustainability and; which incentives they need to engage in collective action.

This last point cannot be overstated. To increase participation, communication needs to be clear about the transparency of the process and provide answers to what happens with the results. It is not only pertinent to identify and activate less powerful and marginalised groups but also to organise collective action in such a way that allows these groups to participate in a meaningful way. Given that some barriers to participation may be difficult to overcome, especially those related to time availability and flexibility, it is critical that the citizen engagement is at the very least aligned with low entry barriers, by a) using language as close to the private sphere as possible; reducing steps, clicks and distances necessary to participate, combining on- and offline spaces; fostering trust in individual competence, that everyone feel they can participate regardless of their skills; demonstrating the potential impact of participation they can have; offering incentives, e.g. compensate participants (Itten et al., 2020). Overall, energy communities should be

cautious about their claims of being inclusive, as many initiatives might initially attract members of higher socioeconomic status to a much higher degree (Pape and Lim, 2019).

4.4.4. Implementing stakeholder agreements

During the implementation phase, the group of stakeholders shifts from negotiation to action. A proposed approach is broken down into activities and a division of labour has been agreed upon. For energy communities, it might be beneficial to install some sort of oversight board that oversees implementation and reacts swiftly on potential problems.

There are some important considerations for this phase, since the implementation phase of multi-stakeholder management tends to differ between the management and negotiation phase. It may be the case that an agreement is negotiated but that it is not, or only party implemented subsequently. There can be numerous reasons for this (Itten, 2018): Implementation is less likely if not all of the relevant actors were fully represented in the decision making arena, especially those that have enough leverage to block or delay the project. Or if the representatives participating in the procedure did not get the backing of their respective organisations and members. Additionally, to what degree a project or solution is implemented is not only down to the willpower of the participants.

Three points are important in this respect: First, the political willpower of the municipality and the council to support the project of a collective action must be considered, especially if they are not involved in the process. Second, there must be sufficient budget allocated and legislation must allow an implementation. Third, argue that the output of a multi-stakeholder participation process should have a genuine and visible impact on policy creation, in order to foster the self-efficacy of participants (Itten, 2018). The commitment of powerful stakeholders to implement an agreement after it has been reached is an important factor and shows the level of resilience of a collective action. While multi-stakeholder networks can be very effective, their sphere of influence will always be confined to the willingness of their participants to live up to the commitments made in the network (Roloff, 2007).

Some multi-stakeholder networks are likely to institutionalise and continue with dialogues and negotiations. Others, however, will dissolve, because the negotiations fail to meet the participants' expectations, or because their results are incorporated into laws and regulations. Even if the working objectives cannot be fulfilled, research has shown that there can be a positive experience for energy communities from a functioning multi-stakeholder management nonetheless. They can lead to an increased learning and trust between stakeholders, and participants might realise that cooperation has proven to be reliable for future tries (Roloff, 2007).

4.5. How digital technology is used to support energy communities

Digital technologies have drastically transformed the contexts and processes associated with collective action. Communities and grassroots movements experience fundamental changes in the ways they approach social and political issues, in how resources are

allocated, and in how new and passive members are activated and how information is distributed in their networks (Young et al., 2019). Digital technologies and social media have created new resources for citizens to acquire information about public problems and data about themselves that make them more competent partners in public problem solving (Fung, 2015). The application of these technologies has enabled collective actors capable of intentional, strategic action, who are shaped by cross-situational institutionalisation processes during which distinct group identities, shared rules and goals (Dolata and Schrape, 2016).

As collective action in sustainable energy is increasingly shifting into the online realm an important starting point is who will participate? Experience shows that younger citizens prefer the use of online forums more than communication face-to-face. Young people are far more likely to be represented in digital collective action due to their capability and willingness to engage online. Indeed, collective action studies show that the frequency of internet use is the main predictive factor to get engaged online, followed by political motivation (Norris, 2005). Yet on the other hand, the online behaviour of youth is rather focused on getting information instead of intensive participation. A study conducted by Hargittai and Shaw (2013) states that younger citizens are also more likely to engage in "low-intensity" forms of political action, such as "clicktivism", signing petitions, or donating. There is still more research to be done if the low threshold and low cost result in low impact as well, or how it specifically translates into real action in the physical world (Young et al., 2019). Many citizen-initiated groups on social media are often able to attract hundreds or thousands to join their cause, but many of them have not been effective in converting their online activism into formal planning, organisational or policy processes (Evans-Cowley and Hollander, 2010). Other than that, caution needs to be exercised against disenfranchising poorer groups or segments of society, if collective action shifts to be increasingly digital. Participants who prefer online participation practices to paper-and-pencil tasks or face-to-face meetings differ from their counterparts on a number of sociodemographic variables. Most significantly, older adults stick to using traditional media and even though their numbers in online participation increase, Xie and Jaeger (2008) show that older adults have negative intentions to change their political participation systems from offline to online, especially the age group 65+.

There are further important design considerations that need to be taken into account. For example Shortall and Itten (2020) point to the trade-off between user accessibility, a well-structured discussion and an understandable visualisation of the most relevant topics and arguments. Arguably, most online discussions happen on easy-to-use conversation-based platforms like forums, but their ability to promote fair and transparent discussion is debatable. Posts organised topically can support navigating and connecting content and linking participants to each other. Other platforms visualise discussions and map out arguments, with argumentation trees, or systems maps, helping participants to clarify their thinking and better connect information. These platforms may require user

training or supervision, but they promote fair and rational assessment of choice alternatives (Shortall and Itten, 2020).

Another consideration needs to be made about synchronous or asynchronous interaction. Choosing between a synchronous or asynchronous environment creates a trade-off between a more "real-life" experience and a more reflective and inclusive one. Real-time chat or video is more spontaneous and helps to build rapport between participants. Asynchronous communication, on the other hand, allows more time for self-reflection, removes location or time restrictions, and increases access for people with slower internet speeds. It is a way to "level the playing field" between the more and the less informed participants (Neblo et al. 2010; Shortall and Itten, 2020).

There are digital platforms available for collective action in general and for energy and climate related issues in particular. For example, there are crowdsourcing platforms that are specifically good at generating ideas and visualising the argument space, other platforms are better in mimicking some of the small-group kitchen table experiences. Another section of software supports peer-to-peer trading or helps with decision-making.

The following part provides an illustrative overview into different technologies, software types and start-ups (without claiming completeness):

4.5.1. Community communication and virtual engagement

Social media is often used as a supplementary channel of engagement. Social media is a powerful tool for both organised and decentralised collective action initiatives. Citizens can mobilise and connect easily with perspectives on an issue; vet information with first-hand and in-person accounts. Social media facilitate forming groups around common causes, be it to organise a collective citizen action in the energy transition, or to expand its members. Groups in this context are different from organisations because they generally are fluid and lack formalities, and membership can range from short to long-term. Citizens function as content producers and information moderators influencing behaviours of other citizens (Seo, 2019). The negative side of social media is however that it is prone to spreading disinformation, creating echo chambers, accelerating psychographic profiling and polarisation. Besides the big well known social media platforms, several small players focus on the community or neighbourhood level, which might be more suited to initiate and sustain local energy collectives.[8] Increasingly, cities and municipalities have also established their own online community spaces. Most collective actions start from where their citizens and target groups are located, and depending on the context and their online capacities, and only when they are saturated they begin to expand their communication spaces.

In Som Energia (Spain), a social network platform has been created to foster the interactions between members and to enhance the democratic vitality of the cooperative.

[8] Nextdoor.com; hoplr.com; nebenan.de ; mesvoisins.fr; OurCommonPlace; Front Porch Forum; Community Remarks

There are further efforts to create virtual social energy communities, with the intent to help cooperatives or other communities to manage their operations, engage with their user base and to activate more members through various functionalities (REScoop.eu, 2020).

4.5.2. Online consultation and deliberation

Through online consultation groups of people are asked for their opinion, preferences or advice on one or more specific topics. There is a wide range of platforms and providers for online consultation.[9] While some allow for trade-offs between different planning, project or policy scenarios, others are focused on gathering pro or con arguments for different proposals. The idea is to make project proposals or legislation accessible to a wider public and at the same time including everyday knowledge from those affected by the proposed project or legislation.

Since discussion and interaction between users is often limited in online consultations, online deliberation tools offer the chance for asynchronous deliberation (text/argument representations), synchronous (real-time), chat- or video-based interaction. Deliberation allows a number of people to discuss shared problems, enhance critical thinking, and formulate solutions. Deliberative online platforms ideally strive to promote respectful and thoughtful discussion. Their potential to reduce polarisation, build civic capacity and produce higher quality opinions (Strandberg and Grönlund, 2012) are much discussed in the literature. To date, many platforms focus on small-n deliberation, but lately there have been efforts to expand the number of users, and make deliberations accessible to the many[10]. Fishkin et al. (2018) for example developed the "Stanford Online Deliberation Platform," which uses an automated moderator to support constructive discussions. An automatic moderator encourages participants to consider arguments from both sides while maintaining the civility of the discussion. In addition, the artificial moderator distributes incentives discussion phase, the artificial moderator participants to a collaboration phase. This phase motivates the participants to develop a number of questions, solution ideas, or action items. In addition, there is monitoring for offensive or harmful content. Participants can give feedback to the moderator whether a post should be deleted or a user should be blocked. Yang et al. (2021) use the Case-based Reasoning (CBR) technique to promote better idea generation, reduce negative behaviour, and stimulate consensus-based suggestions on discussion platforms. Indeed, many technical developments seek to help participants reason with each other and make joint decisions. This can be a valuable strategy for energy communities that want to enhance their internal democratic decision-making processes. Gamification can be considered an important addition to developing digital deliberation interfaces too (see Section 4.5.5.).

4.5.3. Crowdsourcing

Crowdsourcing is a phenomenon in which a community calls upon the knowledge of both professionals and amateurs. To help solve a problem, design a product, or analyse large

[9] Populytics; Cityzen; CrowdHall; bpart.be; citizenlab.co; MetroQuest; Citizen Space

[10] Deliberatorium, D-Agree, Regulation Room; considerIT; Kialo; liquidfeedback; discourse

amounts of data, energy communities can make use of crowdsourcing platforms[11]. Collective data collection can include collective assembled documentation such as internal records, statistics, reviews, research, personal research diaries. An important approach is also participatory observation and fact finding, that includes data related to direct observations, reflections and sensing. This can also include collective interviews between citizens, experts and policy makers. Such crowdsourcing can lower costs and can yield greater quality and speed than through conventional research. Self-satisfaction is a reason why individuals are drawn to solving problems for other people, and frequently financial incentives are the driving factor.

An example where crowdsourcing is important is demand-response flexibility. With the continuously growing renewable energy generation, users need to be flexible in adjusting their energy consumption, giving rise to demand response mechanisms. In these programs, an aggregator schedules a demand-response plan in the day ahead. Customers join the demand response plan voluntarily for monetary credits (rewards). The problem of optimally defining the amount of flexibility requested by each user (in a commitment-based approach) or the amount of financial incentives provided to each user (in an incentive-based approach) is currently drawing significant attention (Pichler et al., 2019). The integration and active participation of citizens and stakeholders into research and development of demand-response flexibility processes in early stages is crucial, not only to integrate citizens' values and needs into proposed solutions, but also for their effective application in everyday life (Pichler et al., 2019).

4.5.4. Marketplace and peer-to-peer trading

Residents or communities who generate their own electricity often produce more energy than they require. Typically, this excess energy is anonymously transferred into the energy grid. However, startups are currently developing software that enables private and community energy producers to share their surplus electricity directly with other members of their community, such as neighbours, schools and hospitals. Peer-to-peer (P2P) energy sharing has emerged as a decentralised market platform that can facilitate the independent decision-making process of prosumers to trade their energy within a connected community (Tushar et al., 2020). Encouraging community members to interact with one another to share their energy, P2P improves social values within the members and helps them to establish an environment-friendly neighbourhood. Shifting to a decentralised sharing economy model reduces the greenhouse gas emissions from big power stations, increases choice, and transparency. Thus, P2P empowers the prosumers and gives them the independence of the energy they produce and manage. Moreover, P2P energy sharing schemes focus on a widespread set of norms and motivations, such as on the participation and inclusion of residential households, the reducing of energy cost, the

[11] InnoCentive; OpenIDEO; Street Bump; Ushaidi; Upwork

balancing supply and demand, reducing peak load, and managing network loss (Tushar et al. 2020).

Tushar et al. (2020) as well as REScoop.eu (2021) present a collection of European P2P community projects in Austria, Germany, Spain, Italy, Netherlands, Norway, Finland, Slovakia and the UK. For instance in Germany, ShareandCharge is a blockchain energy market for EV charging transactions, and data sharing. Sonnen Community in Germany considers solar and storage systems to create a virtual energy pool. In the Netherlands, Powerpeers, a start-up owned by Vattenfall, supports P2P for residential buildings to share their energy with one another using a blockchain-based energy market. Another blockchain example is the Pylon Network from Spain, which developed an independent and neutral database based on blockchain technology, giving end-users much more control over their private production and consumption information. The energy cooperative FairCoop in Austria on the other hand uses a blockchain technology including a cryptocurrency with a clear set of values, to reduce the amount of energy needed for secure transactions. Another online marketplace connecting people with green local electricity is the Austrian OurPower's platform. It allows producers to sell their renewable energy directly to friends and neighbours, and provides more transparency into energy trading.

In Norway, EMPower provides a trading platform for local energy exchange between prosumers in a local market, whereas Piclo is a UK based software platform for selling and buying of smart grid flexibility services and P2P energy trading. Fuergy, a Slovakian startup, has a mission to make renewables effective and affordable to everyone. They use an artificially powered device that helps users optimise energy consumption and maximise the energy efficiency of renewables.

A notable community-driven energy example outside Europe is the New Zealand-based Our Energy. Its platform matches real-time data from those producing their own electricity with others in their communities. This allows renewable energy producers to sell their surplus energy to local consumers. The platform keeps track of the energy sources and the buyers' consumption data. It also enables producers to monitor their energy prices.

Focusing on sharing renewable heat, the Canadian startup Cascara Energy enables thermal energy sharing through community district energy networks. The startup recovers waste heat from landfills and wastewater streams as well as from data centres and supermarkets. This recovered waste heat contributes to the heating and cooling requirements within the community. The startup also stores the surplus energy in a seasonal thermal energy storage facility to reduce grid peak demands.

Arguably, the decentralised renewable energy sector is one of the early adopters of blockchain technology. There are many attempts for promising applications, but implementations often lack a holistic, citizen-centred point of view. It is therefore necessary for energy communities to keep up with, and shape these developments, as this domain is currently heavily driven by technology start-ups. Some of these initiatives

exclusively focus on technological disruptions leaving aside further social and economic consequences (Pichler et al., 2019).

4.5.5. Gamification

Gamification, as a design to influence motivation and engagement, has gained increasing awareness in recent years. The functionalities of gamified environments in the sustainable energy sector are many. Examples are reward-based approaches to award users based on their activities, or stimulating inter-user competition, others may use collaborative reward structures that provide incentives for improving social connection, reaching a consensus or taking collective action. There are further gamification designs such as discussion points; virtual money; peer rating systems; shared narratives; progress bars; leaderboards and missions (Guillen et al., 2021). Hence, gamification can be an important addition to developing digital tools for energy communities. However, as Hamari et al. (2014) note, positive outcomes from gamification depend heavily on the context and the characteristics of users. Gamified systems are strongly linked to citizens' actions in relation to their energy consumption, conservation and other sustainable practices. However, individuals need to be not only aware of their own responsibility but also about their capability to produce an outcome with a wider impact than their mere individual satisfaction. Gamified systems for energy communities should explore ways to visualise the results of the choices made and facilitate comparison, either as part of an individual progress-check or within social frameworks. The latter works best when there are comparative targets or levels of ambitions between neighbours or family members (Guillen et al., 2021). Another example is the Horizon 2020-funded “Socialenergy” project, which develops a gaming and social network platform for educating energy consumers and virtual energy communities. The proposed platform is modular by design and facilitates the easy, rich and deep communication among involved stakeholders from individual energy consumers and virtual energy communities, to utilities, policy makers, and even other indirect stakeholders (such as electric appliance retailers and building renovators) that will allow them to: a) discover each other, b) educate themselves in order understand the difficulties and challenges that each one faces, and c) interact and trade among the participants (Makris et al., 2018).

4.5.6. Cybersecurity and data protection

The increasing use of intelligent distribution algorithms in smart grids, the proliferation of the internet of things and home sensors for energy consumers provide a challenge from a security perspective, as it makes control devices susceptible to vulnerabilities of IP networks and makes them accessible to threats from the internet (Pichler et al., 2019). Attacks can be focused on critical infrastructures, such as power distribution networks, they might be politically oriented such as in the Ukraine energy grid attack in 2016, or they can be financially motivated. Clearly, they become increasingly diverse and sophisticated, and target smaller organisations. Recently, a cooperative of corn and soy producing

farmers in Iowa suffered a large ransomware attack that locked their computer networks used to keep food supply chains and feeding schedules.

Even though European energy cooperatives might have not (yet) been targeted, cyber-attacks can cause malfunctions, mislead smart meters and distribution networks, distort power grid data, or violate user privacy by extraction of sensitive information (Pichler et al. 2019). An extended overview for threats for energy communities and smart grids can be found in Kounelis et al. (2017).

Protection against cyber threats can therefore be considered an important task for energy communities. Risk mitigation strategies that communities might find helpful are (Nicol, 2021): a) phishing and email protection: phishing attacks come in the form of unsolicited emails and suspect social media posts, including malicious links or attachments. There are services that look for evidence of malicious intent and may take corrective action, but software updates and employee training are crucial too. b) a backup that cannot be changed, altered or encrypted by a ransomware attack. c) practising with potential (but inactive) threats. d) Data protection programs observe patterns of data access and usage. Professional cyber security assessments are aimed at helping an energy community understand its maturity level with respect to managing the potential of various cyber risks for its system operation. In a standard assessment the following areas are usually covered: cybersecurity risk management; configuration and access management; threat and vulnerability management; situational awareness; information sharing and communications; event and incident response and continuity of operations; supply chain and external dependencies management (Nicol, 2021). An extended overview for mitigation strategies for energy communities and smart grids can be found in Kounelis et al. (2017). In the US, the Rural Cooperative Cybersecurity Capabilities program helped more than 500 energy cooperatives to build stronger cybersecurity programs with a focus on developing tools, resources, and training opportunities for improving their cybersecurity capabilities.

A further important issue for decentralised energy systems is the compliance with the General Data Protection Regulation. Energy communities have to be careful when selecting which data will be collected, how it will be processed, anonymized and which data will be transmitted. Data and all communication channels need to be protected from unauthorised access and its integrity needs to be ensured in line with GDPR compliance (Pichler et al., 2019).

4.6. Making socio-technical energy more receptive to social energy innovation

Community energy does not only offer tremendous social and environmental advantage over fossil fuels, it also challenges their concentrated power and high rates of return. Concentration often delays the local energy transitions until mechanisms are in place for them to transfer their centralised model to a renewable energy system. According to Burke and Stephens (2018), the overall energy transition proceeds slowly so as not to disrupt capitalism (as in meeting projected demand) and due to limited market opportunities.

Strong community energy, according to the authors, is focusing on a more distributed energy system, strengthening democratic access to energy, and accelerating the low carbon transitions. Community energy is characterised by community-based control across all elements of renewable energy systems, from extraction to operations to disposal, and from resource collection and generation to transmission and distribution to storage and end use, and as such can be viewed as more a democratic opportunity than an economic opportunity (Burke and Stephens, 2018).

4.6.1. Lobbying for social energy innovations

For community energy to flourish, it is important that their voices are being heard in the political decision-making process. Innovation movements are facing regime barriers and incumbents who see their taken-for-granted position in the energy system as challenged, and who may seek to co-opt or eliminate the innovations (Geels, 2014). Hence, trustful and enduring ties with local, national and European political institutions ensures a better representation of the interests of community energy. This requires active participation in the policy circle. Otherwise unequal participation translates to unequal representation. The absence of political competition will favour centralised energy systems, high market barriers and transaction costs or remuneration schemes that are designed to favour large corporations (Kooij et al., 2018). If the political field is left to corporatist culture and regime actors, then change will be equally slow as it has been in the past.

It is important to differentiate between lobbying efforts to public officials and elected members of the local council. Council representatives can bring facilitation skills and connections within and from the council, however they are more inclined to listen to their voters, as seen in aggregated polls, in social media traffic, etc. They are also more concerned about their own re-electability and are more strategic about their political objectives, which often translates into their legislative actions. The latter is also of concern as community efforts and public participation are often a complementary, or confronting effort to rule-making in the council. Hence, when collective action is lobbying to politicians, especially to those that are not predominantly supportive of their action, it is important to take these points into account and develop effective win-win strategies.

Supporting remunicipalisation of grids and other energy infrastructure can be beneficial for community energy, since smaller or municipally owned energy companies and infrastructure provides a more open environment for collective action (Blanchet, 2015). It can be helpful in building a coalition of energy democracy actors at local and regional levels, as a counter-balance to the large energy companies with centralised production, their market and lobby strength as well as their frequent antagonistic approach to social energy innovations.

4.6.2. Reframing social energy innovations

Moving away from a highly centralised, clearly structured system towards a more decentralised, more fluctuating energy system due to the high shares of renewables will inevitably result in a communication “battle”. As the roles in the future energy system are

less clearly defined and start to blur, some scholars, activists and media outlets frame it as a “disruption”, a “David against Goliath" story or as “systems change” (Dütschke and Wesche, 2018). While this is generally positively received by actors that support energy democracy, it can also evoke different connotations from different stakeholders. As long as the energy community movement is no threat to the socio-technical energy regime, communicative and political action can be expected to be low, the level of ignorance high. However, once energy communities are moving beyond local markets, incumbents will certainly try to connect such frames as “disruption” or system change with negative effects such as rising prices or grid instability (e.g. causing more black outs), incompetency, unsolidary to those who are not able to be part of community energy, etc. They will also identify policy makers and municipal bodies that are receptive to negative frames of community energy. Hence, it is not only important for energy communities to communicate their benefits from carbon reduction to societal support, but also to show that they are able to counter negative frames, i.e. that they are neither threat to energy stability nor higher prices, but opportunity for shaping the future energy system and energy grid to face the challenges of the energy transition (Blanchet, 2015).

5. Evaluation and monitoring

One of the main objectives of the SCCALE 203050 project is improving the ability of RECs to track and accelerate their progress. This means facilitating evaluation and monitoring practices. In this chapter, attention is paid to how energy communities mature, to the stages of change that apply in this maturing process, including insights into (and a framework) of collective actions that pertain to different stages of change energy communities go through, and finally the relations of the maturity model and the associated actions to developing the Development Progress Tool (i.e., Deliverable 2.2). The Development Progress Tool is to be used, tested and validated in SCCALE 203050 with the implementation of five demonstration pilots.

5.1. Maturing energy communities

Seebauer et al. (2022) define maturity as the resilience and robustness of an energy community against unexpected changes in the energy system. It can be seen as an ideal a community may want to achieve. According to this definition, a community is resilient and robust when it is capable of coping with external influences of the energy system by responding in ways that maintain its essential function and structure while it also maintains its capacity for adaptation, learning and transformation. In other words, maturity means that a community is able (i.e., capable and willing) to respond to a favourable environment by recognizing and profiting from opportunities as well as to respond to an unfavourable environment by minimising risks, improving workarounds for adverse impacts, and bouncing back to a stable state.

To assess maturity, Seebauer et al. (2022) developed a framework and scale[12] in order to provide insights in the level of readiness, the growth and the environment of an energy community. The goal of this maturity scale is to help communities understand their strengths and weaknesses, and to guide them on their way to a mature, stable and democratic organisation. The maturity scale and framework were developed to assess and reflect on three main criteria (*Ibid.*):

- Democratic representativeness: the capacity of an energy community to represent and execute the will of the local citizens living in the community.

[12] The development of the maturity scale and framework that are presented in this document has been conducted within the COMPILE project. It only reflects the COMPILE Consortium view and the European Union is not responsible for any use that may be made of the information it contains. The maturity scale and framework, and their content are the property of the COMPILE Consortium. The maturity scale and framework are licensed under a Creative Commons Attribution 4.0 International License (CC-BY). https://creativecommons.org/licenses/by/4.0/

- Market impact: the capacity of an energy community to take on an active role in the energy system. Theoretically, this can be perceived as energy communities contributing to transformative change in energy markets.

- Supportive environment: the extent to which an environment, in which the energy community operates, is supportive or not. Theoretically, this is about the organisational and institutional environment of energy communities being favourable in supporting their operations and strategies. For example, a supportive environment might include supportive financial and regulatory schemes, and provide intermediary agents that support capacity building of energy communities, and translocal networks that support knowledge sharing and provide guidance in how to further develop and mobilise resources in cooperation with other actors.

A community performing well in certain maturity indicators is assumed to be better prepared to seize on the opportunities and react to the challenges of the energy system.

As REScoop.eu puts it, the maturity scale is primarily intended for self-assessment of communities who wish to understand their current development stage and who wish to identify aspects they might address in order to improve their position in the energy system. Furthermore, the maturity scale allows for comparison of communities that vary in terms of maturity. In doing so, the maturity scale can help to provide examples of good practice or even failure (i.e. from previous/existing communities) that may help to reflect on certain scores assigned to specific indicators, learn to overcome certain challenges (related to low performance) and suggest actions for improvement.

Determining the level of maturity in energy communities requires the definition of good practice in a reference model that outlines a development's lifecycle, objectives, outputs and relationships between them. These reference models are refined into areas and activities which exemplify the practices of a collective energy action, and more importantly, reflect the needs of the intended users.

5.1.1. Stages of change

The maturity scale and framework developed by Seebauer et al. (2022) are based on the stages of change framework to explain the development of community energy initiatives (Bamberg 2013) and are extended to collective action. The stages the maturity scale discerns are in time order: contemplation, preparation, implementation and maintenance. After discussion within the SCCALE 203050 project consortium this was changed into: inspiration, preparation, implementation, and operation. For each of these stages, the maturity scale assesses five so-called areas, such as social (community) social (staff), financial, technical, political and learning (Ibid.). In order to assess the stage of change for any given energy community at a given moment in time, and how it can be elevated to the next stage, the maturity scale provides indicators per stage and per area (See Table 4). These areas comprise of:

- A Social area (community): Community factors are meant to assess the integration and level of engagement of the members of the (local) community.

- A Social area (staff): Staff factors refers to the capability level of the staff members of the community energy organisation, such as human capital, the knowledge and skills that will allow an energy community to implement their services and develop new ones.

- A Financial area: The financial area refers to the financial capabilities of the organisation, such as market values and business indicators linked with the entity built by the community. The typical energy community tends to be on the conservative end of the spectrum (risk averse), in order to ensure a long term growth path.

- A Political area: The political area refers to assessing stakeholders, i.e. who and where are the allies (and enemies) of an energy community as well as its projects and services? Exercising power in (public) decision-making is evident here. This includes having good relationships with political actors and public officials "to get things done". The political area also involves the assessment of administrative, public policy and regulatory barriers.

- A Technical area: The indicators of the technical area are related to the knowledge and technical capabilities of the community entity to provide stable services. "Technical" applies to both technological systems and options, as well as to techno-economic operational activities.

- A Learning area: This area focuses on the education of the staff and members. It also addresses critical reflection on one's REC own performance (and should include both first and second order learning). Learning is considered one of the key principles of the successful creation and development of an energy community, as well as it is referring to the capacity to adapt and learn as the market evolves. Diffusion of lessons learnt is also important as it is very likely that members of an existing energy community are the founders of another energy community. In this report we consider issues related to scaling community energy also as belonging to the learning area. Closely related to learning and diffusion of lessons learnt, is ideation of how REC practices, tools and institutions can be scaled. This could refer to the multiple ways in which scaling is conceptualised (See Section 2.5.7).

Table 4 presents an overview of the four stages of change, and the collective actions energy communities can undertake. The four stages of (organisational) development and maturity pertain to: stage 1 inspiration; stage 2 preparation; stage 3 implementation; and stage 4 operation. These stages resemble to some extent the development stages citizen

collectives' go through as developed by BuurtWarmte (2020) and TNO (2020) in the Netherlands and applied to the sustainable heating transition.

Furthermore, Table 4 also includes a set of actions per development and maturity stage. Per stage, actions are subdivided into the thematic areas that have been presented priorly, i.e., the social area (local community), social area (staff), financial area, political area, technical area, and learning (and scaling) area. Here, it is assumed that once energy communities succeed in implementing most actions in one stage this allows them to move into the next stage. In other words, if a certain minimum threshold of actions in one stage is reached this allows them to move into the next stage and conduct actions and activities as per that stage. The set of actions presented in Table 4 forms an extension of the set of actions belonging to the maturity scale and framework developed by Seebauer et al. (2022).

Theoretically speaking, if all actions are implemented well and the last maturity stage is reached (i.e. operation) one may assume that an energy community succeeds in maturing, developing an organisation that runs one or more projects, performs generally well, and has both social and environmental impact (e.g., generating and supplying renewable energy, and contributing to greenhouse gas emission reduction), although performance on these indicators is arguably also reached in earlier stages (like in the implementation stage). At the operation stage one may also assume that the energy community is actively engaged and succeeds in scaling its operations, business model and practices, even contributing to transformative change in the energy sector (or at least locally or regionally).

To measure maturity the items used in the maturity scale use two types of indicators: (1) threshold indicators and (2) continuous indicators:

Threshold indicators refer to tipping points; when passing the threshold, the community undergoes profound change in its organisational structure. In the Development Progress Tool items using threshold indicators can be answered by either yes or no.

Continuous indicators capture the spectrum in the design and outlook of communities. A community's performance on a specific indicator can be scored using a Likert scale (for example, 1-5), where 1 refers to low performance on a certain indicator and 5 refers to high performance. Values 2, 3 and 4 are in between these extremes.

Table 4: *Overview of actions energy communities can undertake subdivided per stage of change and thematic area; extended from the maturity scale and framework originally developed by Seebauer et al. (2022).*

Stage of change	Collective action energy communities can undertake
Inspiration	<u>Social (community):</u> - Formulating a shared vision of the group - Formulating goals, objectives and pathways to achieve them - Voicing and shaping of expectations - Developing a general intention for action - Agreeing on rules for decision-making - Membership growth - Membership fluctuation - Social network formation; i.e., to mobilise resources in social network - Local visibility <u>Social (staff):</u> - Skills and competences of personnel <u>Financial:</u> - Business model in a business plan - Assure cash flow - Integration into existing infrastructure - Resource buffer <u>Political and social legitimacy:</u> - Relationship with local authorities, level of support by inhabitants <u>Technical:</u> - Legal form and scope of the value proposition <u>Learning:</u> - Reaching out to other groups as role models and reflecting on their examples and lessons learned
Preparation	<u>Social (community):</u> - Commitment of members and efficacy of interactions - Human capital - Looking for empowerment by critical actors - Connection/alignment with the local community and stakeholders (e.g. contacting neighbourhood organisations, citizen engagement, multi-stakeholder management, reaching a stakeholder agreement) - Socio-demographic and socio-economic diversity and inclusiveness. <u>Social (staff):</u> - Forming a leadership team - Communication of key personnel and clear management structure - Sufficient staff members with a complete set of competences (e.g., technical, legal, financial, social). - Explore social network environment to add more organisations from which critical resources can be mobilised - Having “project champions” on board - Ensuring board diversity (and inclusiveness) - Contractual founding of a formal organisation <u>Financial:</u> - Profit and loss statement - Available capital and assets, - Reliance on public funding - Cash burn rate

	- Means to generate cash flow (e.g. crowdfunding); exploring funding options and apply for funding - Preparing application of permits or subsidies - Feasibility scan of business case Political: - Number of administrative and regulatory barriers - Relation / connection to local and regional administrations - Seek to find 'political home', i.e. support from public official Technical: - Map technical status quo (i.e. via a system analysis) - Explore and compare technical alternatives and their potential (of future community energy projects) - Conduct feasibility and risk analysis of plans made - Scope and scale of service offer - Support by external technical experts Learning: - Education of the staff and members - Connection to learning platforms / intermediary organisations to help in capacity building - Embedding own organisation in translocal network(s) - Gamification as a learning tool
Implementation	Social (community): - Efficacy of representation, (how representative are the local energy community's members). - Increasing community energy membership size - Visibility of the community energy collective locally - Relating to external actors for implementation support - Socio-demographic and socio-economic diversity and inclusiveness. Social (staff): - Key personnel and number of staff members Financial: - Operational margin - Break-even point - Cash flow ratio Political: - Tracking of political and public support Technical: - Operation of applied technology - Equilibrium consumption / production - Co-ownership of energy project assets - Risk registry - Cybersecurity - Data management plan Learning: - Adapt and learn from the behaviours of the energy market or other energy market agents - Reflexive learning on own projects and performance - Collaboration with research institutes
Operation	Social (community): - Diversity and quality of the engagement of members - Revising rules for decision-making - Refining the shared vision - Socio-demographic and socio-economic diversity and inclusiveness.

	Social (staff): - Diversity of key personnel and commitment of key personnel - Consolidating entrepreneurial skill sets among the leadership team Financial: - Maintaining regular operations and revenues - Return on investment - Debt level - Ratio of financial independence - Interest coverage ratio Political: - Membership in larger community energy networks - Advocacy via political actors and befriended public officials Technical: - Number of services provided - Defects in regular operation - Growth rate in energy produced/consumed - Achieving CO_2 emissions reduction target(s) Learning and scaling - Representation outside the energy community - Growing: reaching out to more households or organisations locally/regionally. - Accumulation: linking an experiment to other experiments. - Assuring replication of own project(s) in other contexts. - "Deep-scaling": improving and enriching current processes in order to enhance the impact on beneficiaries. - Reflexive learning on one(s) own project(s) and performance - Using translocal networks and intermediary agents to share knowledge - "Transformative change": e.g., lobbying, mainstreaming, and framing of debates to enable supportive schemes or change regulations that inhibit community energy performance or growth.

5.2. Monitoring tool

The maturity scale and its stages of change are used as the conceptual basis and framework underlying the SCCALE 203050 monitoring tool, which will help assess REC progress and suggest actions to evolve to the next development stage.

The tool consists of a structured application of KPIs, and provides a series of questions based on these indicators. These questions can then be answered by either a yes or a no for threshold indicators, or a score from, for example, 1 (worst) to 5 (best) for continuous indicators.

As was made clear during the discussions at the TU Delft workshop at the Brussels partner meeting (27-28 September 2021), stages of change are not strictly delineated and may work differently for different projects. This applies to the indicators as well, their relevance and place in the development timeline may differ from one REC to the next. User engagement for example may already start during the inspiration stage before the REC is fully defined, or conversely when it has a service offer available. A REC could also focus on generating impact through education and awareness raising outreach, rather than building renewable energy production capacity. Furthermore, not all indicators may apply

to a given REC, and actions in different categories are likely to be executed by different key members or personnel.

Therefore, the tool allows for manual selection of stages, and gives an indication of the progress in each of these, based on the answers provided. Both questions, actions and stages can be shown or hidden depending on the interests and maturity of the REC under assessment, and action lists can be produced that help the REC progress.

The list of KPIs has been kept general in order to maintain clarity and ease of use, however the tool has at present been set up in such a way that additional indicators, different questions and actions can easily be added and existing ones modified. Furthermore, the tool itself can potentially be expanded with additional functionalities during the subsequent monitoring, testing and evaluation stage that involves the SCCALE 203050 project's RECs. It should therefore be considered a first version, rather than the final one.

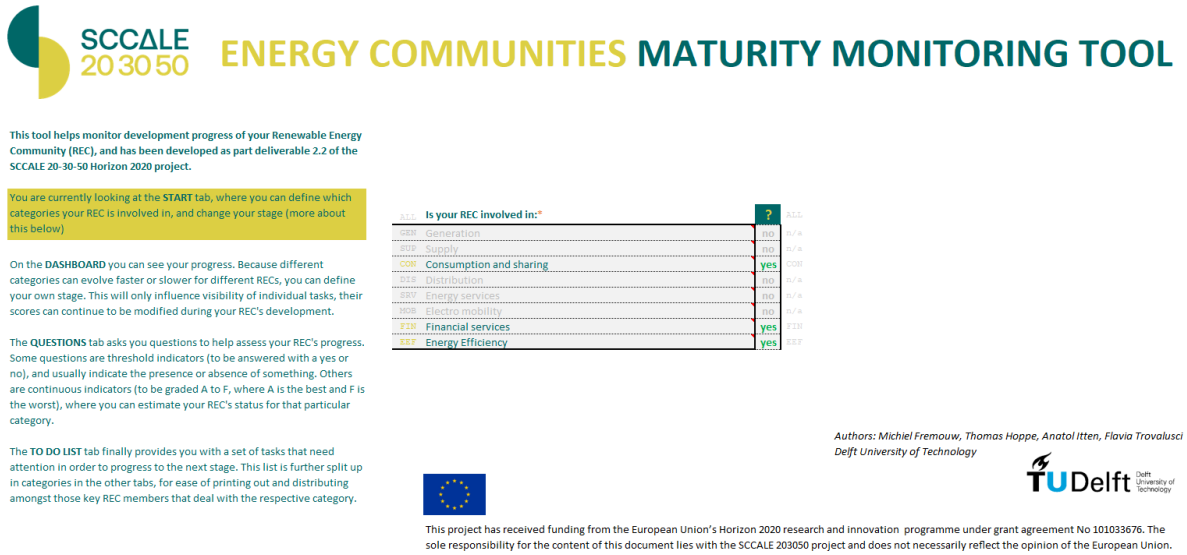


Figure 5: *SCCALE 203050 monitoring tool, start screen*

The Development Progress Tool has been built in Excel, and consists of a number of tabs. The START tab (above) provides general information on the tool, as well as the ability to specify which types of activities the REC is involved in (based on Caramizaru and Uihlein, 2021). This preselection reduces the number of questions and actions, by removing those that are not relevant to the REC from the questions and actions tabs.

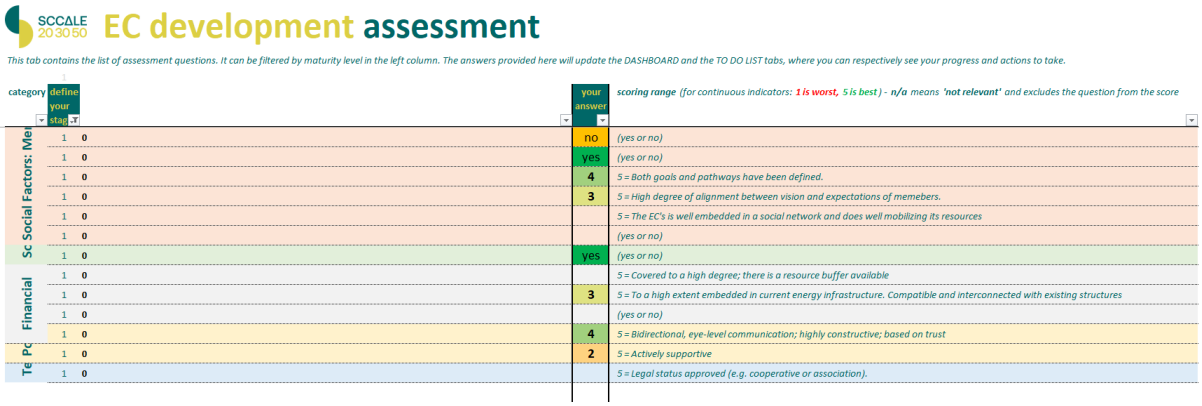


Figure 6: *SCCALE 203050 monitoring tool, development assessment*

The main means of measuring progress is the development assessment tab (Figure 6). Based on which categories apply to one's REC (as specified on the start screen) and which maturity stage has been selected, a number of questions are shown. These either use a threshold scale - yes/no -, or a continuous scale. In Figure 6, examples of both are found. For the indicators using a continuous scale an numeric scale systematic is applied (i.e., with the values 1 to 5), in which the values lie in between 1 (worst) and 5 (best). As the tool is intended to be a self help tool for development progress, and one size does not fit all, individual questions that do not apply to the REC can also be answered with "n/a" (not applicable) to exclude them from the scoring system.

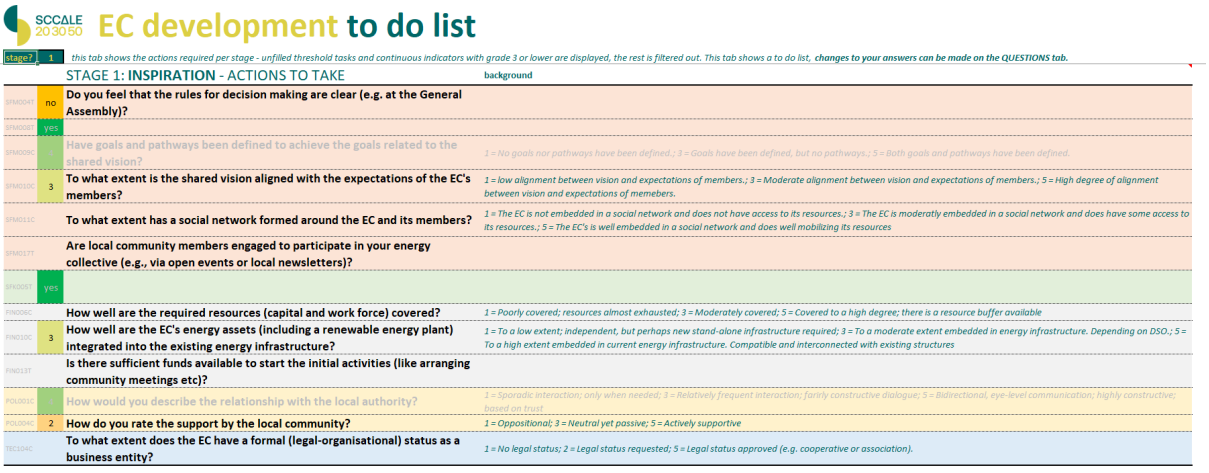
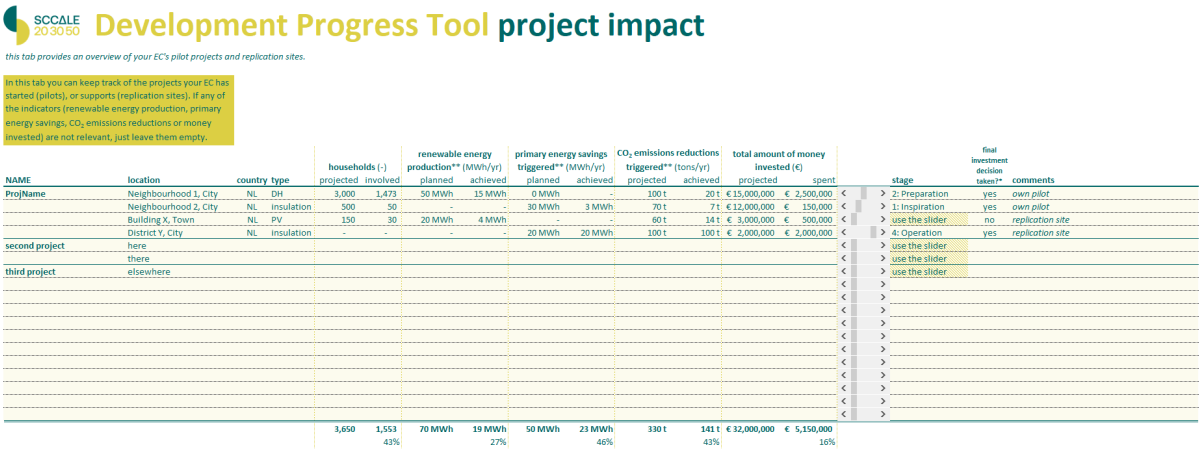


Figure 7: *SCCALE 203050 monitoring tool, to-do list*

The next tab is the to-do list (Figure 7), which shows the actions that still need to be undertaken or improved in order to transition to the next stage. As with the other tabs, the stage of interest can be adjusted so that the list is not overwhelming. Additionally, those indicators whose actions have met the minimum level (either a yes for a threshold indicator, or at least a B for the continuous scale in this example), are removed from the list. This way, the actions listed are only those that are relevant for the current development of the REC.



SCCALE 203050 **Development Progress Tool project impact**

this tab provides an overview of your EC's pilot projects and replication sites.

In this tab you can keep track of the projects your EC has started (pilots), or supports (replication sites). If any of the indicators (renewable energy production, primary energy savings, CO_2 emissions reductions or money invested) are not relevant, just leave them empty.

				households (-)		renewable energy production** (MWh/yr)		primary energy savings triggered** (MWh/yr)		CO_2 emissions reductions triggered** (tons/yr)		total amount of money invested (€)			final investment decision taken?*	
NAME	location	country	type	projected	involved	planned	achieved	planned	achieved	projected	achieved	projected	spent	stage		comments
ProjName	Neighbourhood 1, City	NL	DH	3,000	1,473	50 MWh	15 MWh	0 MWh	-	100 t	20 t	€ 15,000,000	€ 2,500,000	2: Preparation	yes	*own pilot*
	Neighbourhood 2, City	NL	insulation	500	50	-	-	30 MWh	3 MWh	70 t	7 t	€ 12,000,000	€ 150,000	1: Inspiration	yes	*own pilot*
	Building X, Town	NL	PV	150	30	20 MWh	4 MWh	-	-	60 t	14 t	€ 3,000,000	€ 500,000	use the slider	no	*replication site*
	District Y, City	NL	insulation	-	-	-	-	20 MWh	20 MWh	100 t	100 t	€ 2,000,000	€ 2,000,000	4: Operation	yes	*replication site*
second project	here													use the slider		
	there													use the slider		
third project	elsewhere													use the slider		
				3,650	1,553	70 MWh	19 MWh	50 MWh	23 MWh	330 t	141 t	€ 32,000,000	€ 5,150,000			
					43%		27%		46%		43%		16%			

Figure 8: *SCCALE 203050 monitoring tool, projects overview*

Although the main purpose of the Development Progress Tool is to track organisational maturity, ECs tend to develop or support one or more projects that will have a physical and/or societal impact. These can be traditional construction projects like a solar field or neighbourhood home renovation, but also the training of Energy Ambassadors that help households save energy. Progress of these projects can be tracked using the projects overview (Figure 8). Numeric indicators include:

- Number of households (projected / involved);
- Renewable energy production in MWh/yr (planned / achieved);
- Primary energy savings triggered in MWh/yr (planned / achieved);
- CO_2 emissions reductions triggered in tons/yr (projected / achieved);
- Total amount of money invested in € (projected / spent).

As with the Energy Community itself, each project can be assigned a maturity level to indicate its stage of development, and if the final investment decision has been taken. The expected and achieved impacts are displayed both on this tab and the dashboard (Fig. 9).

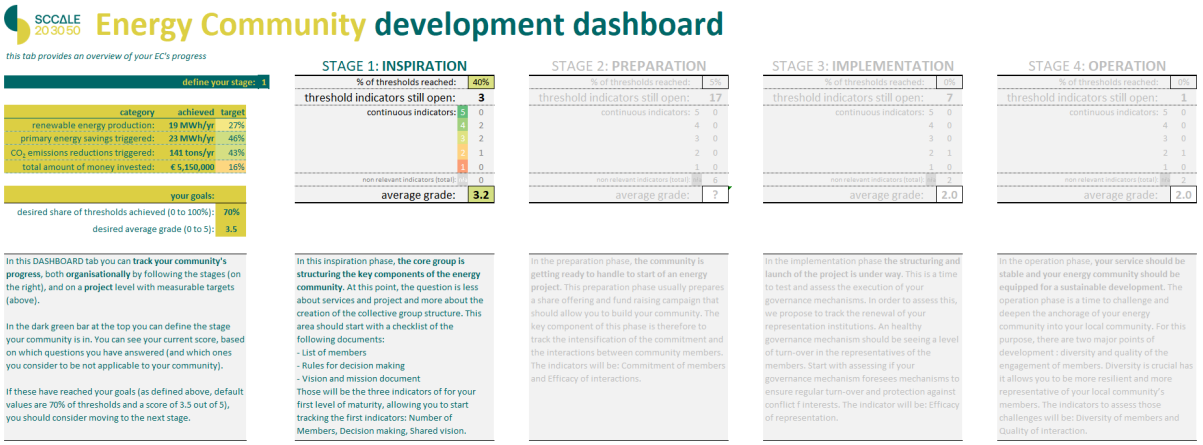


Figure 9: *SCCALE 203050 monitoring tool, development dashboard*

The dashboard (Figure 9) finally shows a visually oriented overview of progress, based on the answers given in the questions tab. The active stage of development can be changed, so that a new user from a starting REC is not confronted with too many indicators.

To assist those in the knowhow and whereabouts of the actions yet to be undertaken, the Development Progress Tool will provide practical web links to places where the required information can be found. This includes a one-stop-shop (OSS), a Toolkit and a community energy library. In the Interreg North-West Europe ECCO project an online OSS was developed where tools, guidelines and approaches can be found that can assist those who wish to establish a REC and engage in the activities previously mentioned: https://www.ecco-oss.eu/. Tools, guidelines and approaches are available that apply to the different maturity stages of RECs. A selection of these are classified per stage of maturity, and will (also) become available in the Horizon SCCALE 203050 Toolkit: https://www.sccale203050.eu/toolkit/. Here, documents and background are available on how to understand and use the tools, guidelines and approaches. This includes information with practical illustrations (e.g., from good practices).

5.3 Monitoring and evaluation process

The Development Progress Tool is designed to allow civic energy collectives to track and assess their ability to operate and accelerate their progress. The tool is based on the maturity scale which is intended for assessment of energy communities who wish to understand - and reflect on - their current development stage and who wish to identify aspects they might address in order to improve their position (Seebauer et al., 2022). Assessment can be done in multiple ways; for example, by RECs themselves (board and/or members) via self-assessment, or via an external person or (intermediary) organisation.

For energy collectives that are in the process of starting up it may make sense to get an experienced REC expert or intermediary involved, and support them in this process by conducting the monitoring process externally, and reflect on and evaluate the collected data before discussing the results with the REC that is subject to monitoring. The expert is expected to collect the data from the REC subject to monitoring, reflect on the data collected, evaluate it, and discuss this with the board (and members) of the REC. Because this is an informative process it is important that the (external) assessor and the REC board (and/or members) are in frequent dialogue with each other. Here it can be assumed that the monitoring process and the dialogue between assessor and the REC subject to assessment also takes place in iterative fashion (i.e. with multiple iterations and loops), in order to promote and monitor progress. The SCCALE 203050 project also includes a Community of Practice (in WP6) and a one-stop-shop (WP4). For young (immature) energy collectives it is desired that they contact experts as monitoring process facilitators via this one-stop-shop.

In order to monitor, data should be collected and assessed. Per stage of change in the maturity scale information should be collected in different fields, i.e., the social dimension (pertaining to both community and staff), the financial dimension, political and social legitimacy, the technical dimension, and finally the learning (and i.e., scaling) dimension. Here, it is important to note that indicators per field vary between the four different stages of maturity (i.e. the inspiration, preparation, implementation, and operation stage). This also means that there is a great variation in the type, amount and characteristics of data to be collected. From here on the monitoring process will be presented per stage of maturity.

5.3.1. Monitoring the inspiration stage

It is important to start with a "baseline measurement". If possible it is suggested that energy collectives start measurements early, just from the situation that a group of motivated persons come up with the idea to start a REC. At this stage there is basically only a small social community that has the ambition to engage in collective action and start a collective with the aim to green the (local) energy system by either producing renewable energy, save energy, increase energy efficiency levels, whilst also trying to achieve some sort of social community goals. In the inspiration stage developments mostly concern social community, technology, and politics. Activities and development in other areas like staff, finance or learning have yet to receive attention, and will receive more of that in later stages of maturity. More in general, in the inspiration stage a citizen energy collective has to become aware on how to organise itself, and has yet to develop any capability to act. Nonetheless, a number of action indicators can already be measured, i.e., developing a vision, setting goals, making expectations, assessing the size of the energy community (i.e. "membership"), social network, local visibility, or access to certain resources (including but not limited to finance).

An overview can be made of competences and skills available among those active in the collective. After the baseline measurement effort has taken place it is recommended to start collecting data and assess them on a semi-annual basis. After the first year data can possibly also be collected in all action dimensions presented under the inspiration stage (i.e., social community, social staff, finance, legitimacy, technology and learning). If possible the annual data overviews are subjected to reflective discussion among those active in the community. The Development Progress Tool should be filled out with data. Based on the data entered into the Development Progress Tool suggestions are provided by the tool on how to continue effort or actions per indicator. Getting directions for next steps is considered a strong incentive for a novice REC to start monitoring. It is also important to get the new RECs in the habit of paying attention to regular reflection on what happened well and what did not, as well as looking ahead.

5.3.2. Monitoring the preparation stage

In the preparation stage energy collectives prepare their organisation to become capable of formulating and preparing community energy projects and related actions. Here, they basically form RECs (most often as an energy cooperative, yet also in other organisational forms known to RECs like condominium associations). Yet, before engaging in actual implementation of projects and actions the REC organisation needs to have a strategy and become capable to act. In the social dimension a strong membership base should be built, there should be sufficient alignment with the local community and the REC is expected to develop a clear vision and strategic plan (with pathways and a perspective on use of resources that are necessary to achieve short and medium term goals, and in the end a long term vision). This should also pay attention to diversity to assure that attention is paid to inclusiveness (in terms of age, gender, education level, ethnicity, and socio-economic status), and avoid that the RECs end up becoming a (typical) predominant homogenous group of persons that represent the local societal make-up only to a low extent, and will suffer from poor social legitimacy and negative attention in the public opinion as a consequence. In addition, the REC is expected to develop a diverse set of skills and competences that are required (e.g. from legal, political, organisational, social-participatory to technical and economic skills). In the economic dimension there should be a clear view on the REC's finance, with reflection on debt, insight on how to generate cash flow, calculation of cash burn rate, and a clear view on available public funding.

At this stage the REC also needs to develop a clear perspective on the (renewable energy, or energy efficiency) projects it want to develop and run, with amongst others a view on stakeholder support, a risk register, starting legal permit request procedures, whilst co-operating with local government and other stakeholders on how to resolve administrative and regulatory barriers. Attention should also be paid on how to embed learning. Furthermore, the REC board should already start thinking about how to reflect on its (organisational) performance, learning on different indicators of its projects (CO_2 emission reduction, affordability, cash flow, social acceptance, public support, perceptions

of the local community, marketing, membership base), and how they can potentially be scaled (taking into account different forms of scaling). This includes giving thought on how to address the professionalisation process that comes with the future development of projects, with several challenges emerging to the REC as an organisation (e.g., selecting the right legal economic form, addressing business case development of these project and related aspects like taxation, coping with emerging value conflicts that can potentially divide REC group members, remaining visible locally, and dealing with personal agendas).

5.3.3. Monitoring the implementation stage

At this stage the REC implements a strategy, with several tactical goals and operational items: e.g., strategies to enhance their organisational performance and reach organisational goals, projects that address renewable energy production, energy efficiency, energy savings or citizen mobilisation, and tools and actions to support the projects and organisational growth. The Development Progress Tool offers multiple indicators that can be used to monitor these. In part they are comparable to the previous (preparation) stage, like monitoring diversity and inclusiveness. However, at this stage it is important to discern monitoring of two levels: (1) monitoring one or multiple ongoing projects; (2) monitoring the REC as (main) organisation as well as its governance structure.

In the implementation stage REC's implement one or more projects. Projects come with one or more actions or interventions, like developing and constructing a solar park, or implementing (a combination of) actions to persuade households to save energy. An illustration of methods used to assess effectiveness of implemented actions comes from the EU Horizon 2020 project "REScoop Plus" which focused on REScoops implementing actions and tools to persuade their members (e.g. individuals and households) to save energy. A methodology was developed by Akasiadis et al. (2017) to statistically assess whether the actions implemented by RECs led to the desired effect. This approach included a process including data collection, treatment and analysis. A schematic overview of the research approach taken is presented in Figure 10. Data collection included surveys, interviews, and group meetings with REScoop experts and data experts, and highlighted the importance of a common data format to be adopted by RECs (to avoid everyone developing a unique version him/herself which turns out incomparable with others because of lack of harmonisation).

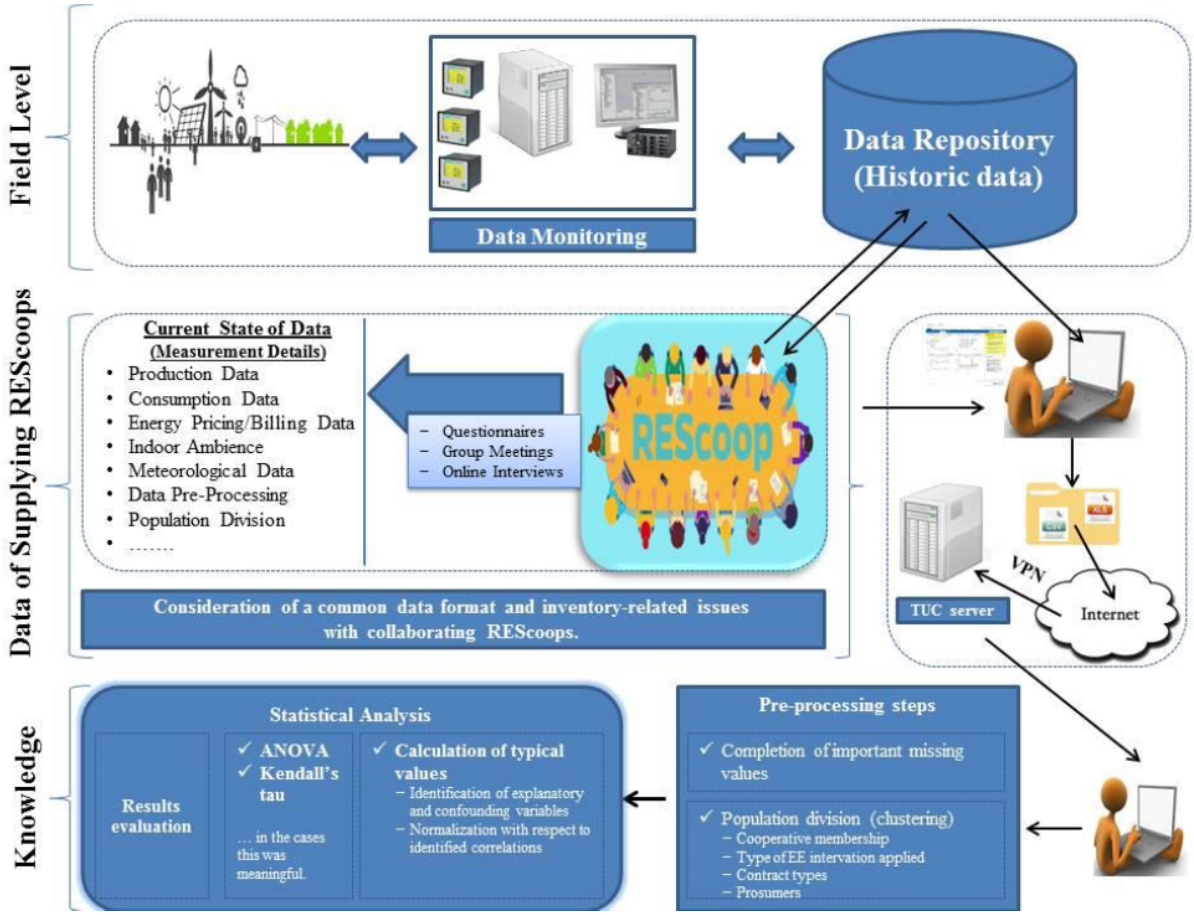


Figure 10: *Schematic overview of the statistical research approach to energy saving actions REScoops implement. Source: Akasiadis et al. (2017)*

In addition to the statistical analysis that mostly focuses on longitudinal analysis, a behavioural or interventionist/"policy evaluation" analysis can be considered, focusing on whether target group members (e.g., REC members or households) changed their behaviours in such a way that the intended goals were achieved (e.g. in terms of adopting solar panels or significantly reducing one's energy use). For the behavioural analysis, a mixed methods research approach was developed in the "REScoop Plus" project to evaluate the effectiveness of selected behavioural interventions (like information campaigns, billing, tailored feedback, or a combination of measures integrated in a holistic approach like "Dr Watt" – designed and implemented by Enercoop; Coenen and Hoppe, 2022). Here, the main task is finding evidence to support claims that the actions or interventions implemented by the REC contribute to reaching the intended goal (like a

certain degree of energy savings, or generating a certain amount of renewable energy). However, attention should also be paid to side effects.

Next to attention to ongoing or recently finalised projects, attention in the implementation stage should also be paid to the REC organisation. In addition to a number of indicators also present in the preparation stage, attention is also needed for indicators like leadership, management processes, dealing with paid employees, ownership of assets (like e.g. solar panels or wind turbines), running operations (at least) break-even, running online platforms, organising reflexive learning sessions whilst critically mirroring actual performance against pre-set goals. Based on experience with the projects and the REC as an organisation attention should be paid to scaling (although there are also RECs that resist any form of scaling – except for deep-scaling - and only aim to improve things locally). These are typical items that indicate professionalisation of the REC as an organisation (which can be host to multiple energy projects, each being registered as a professional legal-organisational enterprise).

5.3.4. Monitoring the operation stage

In the final stage, operations of the REC are monitored and evaluated. Next to monitoring key operational performance indicators also addressed under the preparation and implementation stages, attention shifts to strategic goals and actions. These include achievement of REC's carbon-dioxide emission reduction, energy efficiency, and/or renewable energy and community wellbeing goals. In this stage, also more attention goes to reflective learning and scaling strategies, like one's portfolio of energy services, the REC being an influential member of a community energy network, or having achieved replication projects outside its initial regional context. Finally, critical evaluation and potential adjustment of the REC's vision, goals and main strategy are also part of the operation stage. In this stage the Development Progress Tool can be used to track and monitor both the REC's own projects as well as potential replication site projects (to which good practice of the REC is scaled-out).

6. Conclusion

The transition to low carbon energy systems cannot rely on technological innovation alone. It also requires taking into account the social dimension of innovation. Because collective action in the form of energy communities can yield positive social, economic and environmental effects, expanding such practices is a justified goal in itself, to moving sustainable practices from experimentation to mainstream. In the context of community energy, this applies to citizen collectives undertaking actions and maturing as organisations and as a movement to increase membership and achieve a sustainable scale of operation, while learning from local energy projects and replicating them successfully elsewhere, with the goals of generating both social and environmental impact. While experimenting, maturing and scaling are obviously aimed to bring benefits to larger groups of society, many challenges are encountered on their way to generate impact. Community energy collectives encounter a plethora of problems like lack of capacity, attracting sufficient funds to run energy projects, they experience volunteer fatigue, they need to develop and adjust sustainable business models, encounter resistance by regime incumbents and experience a mismatch between their strategy and operations on the one hand and policy or regulatory frameworks on the other. Moreover, they often encounter municipal austerity and are distrusted by governmental bodies that are not used to working with citizens and fear losing authority.

As this report lays bare, organisational growth strategies to community energy collectives that provide economies of scale and scope only work when collective action is embedded in the wider community and when citizens participate actively. This happened in the case of Ecopower, an energy cooperative with over 60,000 members, where in the early days members sent a clear signal in favour of starting electricity supply, which not only spurred a professionalisation process but also quick-started regional scaling.

The academic and grey literature offers great insights, theoretical understanding, good practices and tools to address the performance of collective citizen action in sustainable energy, yet it is still fairly incomplete in helping energy communities to reflect, assess and learn from their development in a larger context, and to define new actions that improve their organisational performance, both in terms of strategy and operations. Based on a literature study (Deliverable 2.1 to the Horizon SCCALE 203050 project) the present report provides an overview of how community energy collectives develop, mature, and professionalise. It maps the actions and activities they undertake along the way of these processes. Based on this a qualitative analysis concerning current developments of maturing and scaling energy communities is suggested. Here, the conceptual basis and framework is developed for the elaboration of the maturity index - as developed by REScoop.eu in the Horizon 2020 COMPILE project (Seebauer et al., 2022) - with the aim of developing a monitoring tool (Deliverable 2.2 to the Horizon 2020 SCCALE203050 project) that can be tested and validated in the five pilots of the Horizon 2020 SCCALE 203050

project over the 2022-2023 period. Ideally, on the basis of this report, in combination with the use of the Development Progress Tool, energy communities can gain a profound awareness on where they stand, and what to do next.

In addition to providing the conceptual basis for the Development Progress Tool, this report also touches on other issues that are likely to be of key importance to future development of energy communities. A critical question often raised is whether community energy actually advocates inclusive and just energy transitions, and if not, whether it is able to change course, and how it can use its agency to contribute to this? While many energy collectives strive to be inclusive, many can do more to be representative in their membership to the local population. Mechanisms and good practices to improve accessibility and representation are manifold. Besides communication campaigns, consultations, co-creation workshops, collaborations, various forms of financial ownerships, stakeholder management and harnessing the positive effect of intermediaries are proven useful approaches.

Beyond these, digital technology, such as peer-to-peer trading, blockchain technology and gamification bring about new opportunities. They provide end-users with a lot of insight and control over their private energy production and consumption, they allow a more tailor-made approach to needs and wishes of citizens, and they make participation more engaging and meaningful. Reward-based approaches award members of energy communities based on their activities, stimulate inter-user competition, or provide incentives for improving social connection, reaching a consensus, or taking collective action. At the same time, data protection, privacy and cybersecurity are areas which are not only of concern for mature energy communities, but also for those in the making.

The transformation to decentral locally owned energy systems can also be considered as a competition in framing. Once energy communities are expanding beyond local markets, incumbents will push back with negative frames such as incompetency, high prices or grid instability. Hence, it is not only important for energy communities to communicate their benefits but also to prepare how to cope with negative frames.

Key literature for further reading:

REScoop.eu (2020). Community Energy: A practical guide to reclaiming power
https://www.rescoop.eu/toolbox/community-energy-a-practical-guide-to-reclaiming-power
Abstract: Community energy is key to a decarbonised economy and a crucial step in tackling climate change. This publication is a manual to help everyone understand the steps to create an own community energy project. It includes all the relevant information and practical tips to navigate the field and useful links to more resources. This guide aims to be as useful as possible to people and communities across Europe (and further afield), while also providing some specific answers to everyday questions about community energy.

JRC (2020). Energy communities: an overview of energy and social innovation
https://publications.jrc.ec.europa.eu/repository/bitstream/JRC119433/energy_communities_report_final.pdf
Abstract: The participation of citizens and communities as partners in energy projects are transforming energy systems. Community energy initiatives are offering new opportunities for citizens to get actively involved in energy matters. This report provides an overview of the activities, organisation and implications of energy communities as participants across the energy system. It also aims to inform and identify paths for future policy implications and research initiatives.

BuurtWarmte (2020): 12 steps to a local heat solution
https://www.hieropgewekt.nl/kennisdossiers/in-12-stappen-naar-een-lokale-warmteoplossing (in Dutch).
Abstract: According to the "Neighbourhood Heat" ("Buurtwarmte" in Dutch) platform, an initiative of Energie Samen, federation of energy cooperatives in the Netherlands, it must be clear for players in the field how to realise a heat solution. They developed a 12-step plan for this. The Neighbourhood Heat platform helps residents and energy cooperatives to organise new sustainable neighbourhood heat themselves. Their step-by-step plan provides insight into the process of a heat project in manageable chunks – from initiative to operation. Their four phases pertain to: (1) initiation, (2) development, (3) construction, and (4) operation.

TNO (2020). The Power of the (Citizen) Collective
https://www.tno.nl/nl/aandachtsgebieden/energietransitie/roadmaps/systeemtransitie/succesvolle-wijkaanpak-motiveer-bewoners/de-kracht-van-het-collectief/ (in Dutch).
Abstract: Citizen collectives play a potentially important role in accelerating the energy transition. But how do these collectives form? Which steps do they go through in the customer journey to ultimately achieve realisation? Which success factors and bottlenecks play a role? Based on insights of thermal energy communities in the Netherlands TNO developed a customer journey on how citizen collectives can be established and can operate to support sustainable heating options in neighbourhoods.

7. Reference list

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8. Appendices

Figure 11: Workshop results (photo: Michiel Fremouw)

Table 5: Workshop findings on key-themes for scaling up energy communities in Brussels

TOPIC	OPINIONS
1.TECHNOLOGY	Do not get lost in too many different technologies, but identify steps that are similar to the same regards of the chosen technology
	Mainly ICT and decision-making tools and technologies
	Would focus more on sociological or group dynamics rather that technologies oriented KPI
	Up to the point where it is relevant for the community building process, e.g., how does a process towards a community-owned heating network differ from on 2/2 towards a 3th party community-owned PV-installation

	I think we need to get the model general, and not too technology; people need a generic model without too many details on technology, like the model of REScoop
	Given the differences between technologies (and processes that relate to them), it might be worth including different technologies. If at the end it turns out that there are indicators working for different tech, great, otherwise good to have included from the beginning
	You need to make your technical design more concrete in every step; you could assess the level of complexity;
	Go far, but make sure you also develop in parallel into the social and ecological and political relations behind technology
	Yes, but not for the tech itself. Only for the particular context it creates (specific challenges linked to one or another tech)
	I think technology should be used as a way to differentiate steps between pilots (the technology state will have an impact on the development of the pilots but is not at the core of the project)
	We should be able to have 'option' for each kind of technology but it should not be the heart of it
	Overview of the most suitable technologies should be provided
	Technological specificities are important in the literature in order to understand specificities of project development
	Relate the tech regard to how it affect community engagement
2.MATURITY SCALE	Add maturity scale level as information (so we know); the line should be or proven of creative (or both)
	It is good to use existing, well-established tools and to not reinvent the wheel
	Yes, and link up with the stages-model of REScoop
	Great to have actionable insights from literature with regard to the maturity scale
	Investigate and evaluate the parameters used to scale the projects
	Use insight form literature, but also insights from practice and pilots
	Monitor tool should be simple, literature overview should be thorough, insightful
	I think the literature study must feed the maturity scale giving indicators, steps to follow, but the maturity scale must also evolve by the experience of the pilot
	It might be handy to have a specific focus when searching for info; not strict like, it is good to look into the future when organise
	They should be fully integrated

3.KPI FOR THE NEXT STAGE	By finding micro-steps or actions that will help to reach the "goa" (stage with KPI)
	Include action plans and good practices (there is not one path to follow; a community can grow but also work in depth)
	Reference to elements in the toolkit of this project
	Link each stage to a step of the guidelines
	One possibility could be to identify different types of possible paths (regulatory steps, planning of the project, community building), and then include strategies and tools to reach the next step
	Stages models are always a bit arbitrary and lines easily get blurred; not sure how to monitor
	Highlights: actors, skills, capacities, contradictions (?), enabling conditions, needed to navigate from one step to the other
	Combination of hard parameters, options that indicate more maturity and (probably) a conversation based on examples of existing Ecs
	This is methodology of REC, the strategy for the goal, this is WP3
	Identify best practices that are being used in practice and success factors; my hope is that this is the core of the literature study
4.SOFT FACTORS	If we use scale from 1-10, each grade should have a description helping to decide where on plot locates itself into the scale. Soft factors will always risk to be interpreted differently, so a big amount of information must be given
	Supportive vs unsupportive? Maybe a bit too general
	Maybe link them to a hard factor? E.g., how does a bigger crowd save more CO2
	Are there internationally/commonly agreed standards on how these social factors are operationalized/measured?
	Not 1-10 but 1-4 + examples
	Micro-stories, personal stories, including growth, inclusiveness
5.COMPLEXITY OF MONITORING	Develop a light and heavy version of the tool, small/low complexity project can use the light version
	Make a visual representation (visual support a bit in the style of the ECCO, or made by EPV)
	Do not make it too complicated: a useful tool is a simple tool. Stages-model REScoop makes sense
	Some customization options could be provided? Or different versions of the monitoring tool based on level of complexity
	Maybe diversify in indicators, based on goals that Ecs choose themselves

	To highlight complexity make sure you present limitations and contradictions - not a rosy win-win situation message all the time
	Use the same framework as the methodology
	By sharing real stories with ways on how projects or communities overcame a specific local/social/political challenge; show relative solutions
	It can't be complex: it will be a frame where everything will fit in
	Keep it simple
6.RISKS and OPPORTUNITIES	It can both support and hinder citizens empowerment
	Opportunities: involving everybody, financial independent, many loyal supporters Risks: critical supporters, transparency can make that ideas are in the open
	Involvement, fading-down through time, lack of new energy/new members
	Opportunities: more money and position Risks: nuclear energy, hydrogen, central technologies
	Risks: companies (big) sell themselves as community initiatives, on regulation policymakers still put in place laws that put energy communities at a disadvantage
	Complexity can be depicted by sharing interlinkage between various analysis factors
	Opportunities: the ongoing counter movement against-pollution and capitalism Risks: the strength of the 'traditional forces' that are conservative
	People involvement, political changes, financial equilibrium
7.SUCCESS OF RECs	Leadership, context and political possibilities, finance
	Network formation
	Network formation, learning, shaping of expectations
	Long term engagement
	Democratic, just and transparent governance
	Maintaining expectations
	Have a wide range of knowledge available (tech, communication, organisation), set small realistic goals, reach out to the people outside your community
8.ACCESSIBILITY	Include non-experts views; like for example artworks or local story telling about how a community connects to a certain place
	Open source, free, easily share tools; diversity of format
	Service more accessible to more diverse set of people
	Based on required level of expertise, financial participation and broader

	personal context (e.g., house-owner)
	Add in diversity questions (male/female, age, socio-economic background)
	Languages (also style of columns); active efforts to include diverse groups (workshops to find out from those groups?); include the monitoring tool
	Accessibility: equal opportunity for all community members to join the community + point out externalities for all the community members
	Accessible for every person/family
	Inclusive culture, low financial/other barriers, inclusive use of language/communication/outreach
	It should be in the monitoring tool
	Free, different form of content to be adopted to different people, lot of visibility and communication
	Easy to use, fun to use, affordable to use, clear why you should use it and what impact it has
9.DIGITAL TOOLS	Knowledge data-base
	Online platform to stock documents/share info/exchange between members in a daily/weekly basis
	Google drive for central organisation/collection of documents; platforms for demand-response; online fundraising platforms
	A communication meter
	Social media, Slack, training of people (slides, ppt)
	Government regulatory framework should radically support RECs instead of large fossil fuel companies
	Accessible apps that help people manage their energy use, car sharing,...
	Online MOOC
	Monitoring tool (technological), communication tool (segmentation, contact management), facilitator tool to get members digitally together and make them exchange info
	Slack, Base camp, Signal, Google drive
	Governance, decision-making, transparency, exchange tools (e.g., electricity exchange), rieducational tools, measuring goals and indicators, communication and promotion
	Energie ID
	Platform for communication and interaction (how do we get people to use it?)
10.FREE WISH	Devolve responsibility to citizens
	Allow citizens to seamlessly participate at all stages of the energy system (distribution, supply, production, storage,...)

	The right to make a plan and develop a project and a sound stable price
	Make energy collectives almighty: large an stall investments projects at will (as profitable as we want)
	A different economic and political context that fully support our collective, democratic and sustainable approach
	A responsible legal framework
	Heavily influence the political framework and seize opportunities that should be in democratic hands
	Get the concept more legitimate for investors

SCCALE 203050

Sustainable Collective Citizen Action for a Local Europe (SCCALE) 203050 intends to bring Europe closer to its citizens by fostering the creation of energy communities, taking full advantage of the favourable EU legal framework on citizen energy.

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