Local energy innovators

van der Waal, Esther

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INTRODUCTION

This chapter forms the introduction to my PhD thesis on the role of local energy initiatives as socio-technical experimenters for energy transition. It will first set the scene by introducing local energy initiatives as innovators, leading up to the research question. Afterwards follow the aims and scope, and an overview of main concepts and focal areas of the research. Consecutively, an introduction to key aspects influencing socio-technical innovation by local energy initiatives are presented, together with the sub-questions that laid at the basis of the empirical chapters. The methodology is introduced after this, and the chapter is concluded by an outline of the further thesis.

1.1. Local energy initiatives as innovators

Several pressures are globally fuelling the development of policy agendas stimulating a transition towards a more sustainable energy system. Among these pressures are global climate change, environmental degradation, threats to human health, and not least the impending event of peak oil and related concerns about longer-term energy security. However, not only governments are undertaking action to future-proof their national energy systems. In many north-western European countries, also citizens are re-taking control over their own energy provision, leading to a rapid growth of the number of citizens' collectives in the energy sector [1], [2].

The uniqueness of this community energy sector is not chiefly defined by the applied technologies, but by the particular 'social arrangements through which a given technology, irrespective of its scale or cost, is being implemented and made useful' [3, p. 498]. Community projects are characterized to ideally be open and participatory on the process dimension, and local and collective on the outcomes dimension[3, p. 497]. Seyfang et al. define the sector as including projects 'where communities (of place or interest) exhibit a high degree of ownership and control, [and are] benefiting collectively from the outcomes'[4, p. 978].

These community energy initiatives are far from homogeneous, and are undertaking a broad set of activities, including:

- renewable energy (RE) production,
- collective purchase of renewable energy,
- collective purchase (and installation) of RE technologies,
- collective purchase (and installation) of energy storage technologies,
- promotion of energy efficiency (energy efficiency scans and measures),
- smart grid development and other grid balancing activities,
- participation in R&D and pilot testing of energy technologies,
- and local development efforts.

Community energy can be framed as a niche development potentially able to be one of the steppingstones in realising a transition to renewable energy [5], [6]. Consequently, while aiming to reach climate targets, governments have shown a largely instrumental interest in community energy as potential means for enhancing larger-scale sustainable energy transitions[7] On the one hand as contributors to RE generation, and on the other hand as facilitators of energy related attitudinal and behavioural changes top-down policies cannot deliver[7].

While the work of Hicks and Ison concluded that making a contribution to a more sustainable energy system was the most common motivation among local energy initiatives[8], the rationales of participants themselves are often much broader in scope than energy sustainability. Recent research has identified an extensive overview of motivations for, and benefits of, community energy projects [8]–[11], revealing a list of social, technical, political, environmental and economic impetuses to start a local energy project. Identified drivers for citizen action on decentralized energy systems include increasing local environmental benefits and behaviour within the community; striving for energy self-sufficiency; fostering regional development and income diversification; local empowerment and skills development, and creating actors in a renewable powered future [8]. Oftentimes a combination of projected benefits is found to inspire a project [8], [11], reaching from the personal to the community and the system level.

Even though part of the motivations for starting an energy initiative is supra local, it has been recognised that community energy projects develop in a specific context to meet the particular needs of their local initiators [1]. Hence, searching for societal change through technological change, local energy projects are conceptualised as a social niche. In a social niche 'innovative activities and services are motivated by the goal of meeting a social need and [...] are predominantly developed and diffused through organisations whose primary purposes are social' [12, p. 8]. Such social niches are also characterised in the literature as grassroots innovation environments (e.g. [13]). They represent a bottom-up approach to socio-technical change within the energy system, mainly involving people 'who are intrinsically motivated citizens with a more than average degree of environmental commitment', because of which they use a different set of criteria to select a technology and they are also less interested in future profitability [14, p. 733].

Focused on realising their own local goals, most local energy groups would not be actively concerned with how their innovative practices and the used technologies could be further developed and disseminated [15]. However, there are traces of evidence that citizen's collectives do contribute to technological development and embedment of RE technologies [15]. For instance, the renown wind energy development in Denmark was strongly led by local energy cooperatives [16], [17]. Also, home-insulation policy for socially disadvantaged households in the UK evolved from models that were developed by community activists[18]. Furthermore, similarly, the Austrian solar collector do-it-yourself movement emerged from civil society [19]. Thus, while primarily designed to meet local needs, it has been argued that community projects, frequently unintentionally, still can be conducive of socio-technical change in the larger energy system [13], [15].

For this reason, the community energy sector has been defined by Doci et al. as an internally-oriented niche with a local focus in which technological and social innovations go hand in hand[15]. They argue that community energy stimulates technological development and dissemination of energy sustainability innovations, and they portray technologies as 'tools for actors to reach their special purposes' [15, p. 87]. Hence, community energy could be seen as a social niche in which niche technologies get a platform to develop. Such an interaction and partial overlap between the chiefly internally-oriented social niche for community energy and the predominantly externally-oriented clean tech niche makes for interesting research, since little energy transition research looks at how community energy initiatives help to develop and embed renewable energy innovations.

This is an especially interesting research area as studies on user-involvement in other technical fields show that user communities, such as community energy initiatives, can be significant contributors to innovation [20]. User involvement can take place at different levels of intensity[19]: early users can design completely new technologies (e.g. a specific type of self-built solar collector; they can find and test new applications of a product (such as solar space heating); they can be the source of incremental changes (like the control system or additional security components in biomass heating systems); and they can appropriate unconventional building technologies and design solutions in the course of collective planning processes.

Furthermore, Ornetzeder and Rohracher found that strong participation of prospective users can lead to 'a series of innovations leading to specific design features of these technologies that has been highly functional to a wide dissemination' [19, p. 139]. Thus, involvement of energy initiatives in innovation processes could lead to wider dissemination of energy technologies, as well as technological innovation and design adjustment.

So far, little is known about the interaction between community energy initiatives and energy sustainability technologies. However, ostensibly, contacts between community groups and developers go beyond feedback through necessary monitoring and maintenance of deployed energy technologies, as various examples can be identified of communities actively participating in testing and optimisation of energy sustainability innovations.

Recent multiple case study research conducted by Koppenjan and Hufen describes how some of the Dutch energy cooperatives are actively involved in research and innovation of RE technologies [21]. They show that energy collectives are innovating by gradually renewing their RE systems and expanding the range of services – an example can be found in the wind cooperative Deltawind that branched out to solar [21]. Some initiatives go one step further and are actively taking part in research to develop and improve innovative energy solutions for local application, such as smart grids, smart energy displays, or storage solutions- including amongst others TexelEnergie and LochemEnergie [21]. An international example of local energy initiatives' participation in RE research and development (R&D) can be found in the Scottish Local Energy Challenge Fund projects, which show 'a local energy economy approach linking local energy generation to local energy use' by stimulating collaborative working, innovation and local added value[22].

Hence, indications exist that local energy initiatives can act as socio-technical innovators facilitating energy transition. Based on the current state of literature, this thesis departs from the hypothesis that the community energy niche can help to shape the development of technological niche innovations for energy sustainability in its search for new solutions for various local issues. Furthermore, is hypothesized that the development of locally oriented innovations can increase the transformative capacity of local energy initiatives. Therefore, the following research question is central in this thesis:

What roles can local energy initiatives play in the Dutch energy transition through the development and embedding of socio-technical energy innovations?

1.2. Research aim and scope

This research contributes to innovation studies literature on localised, bottom-up socio-technical innovation by exploring new socio-technical configurations of local community-based sustainable energy systems. Energy collectives combine technological and societal innovations, developing new business and organizational models while embedding innovative RE systems. A better understanding of local energy initiatives as socio-technical innovators contributes to better insight in their transformative capacity as actors in the energy transition. Therefore, the preconditions to and dynamics of their innovativeness are analysed. Furthermore, their future role in the sustainable energy transition can be better understood and potentially also strengthened by carefully aligning new legal, organizational and technological innovations to the needs of local energy initiatives.

The focus in the thesis is on the socio-technical innovation potential of local energy initiatives in the Netherlands specifically, because local energy initiatives' dynamics are heavily influenced by country-specific factors such as energy and planning policy[23], the economic climate and presence of a history of cooperative and other collective enterprising. We focus on the Netherlands specifically because this is one of the few north-western European countries with a flourishing community energy sector. Currently, over 500 local energy collectives are active in The Netherlands, many of them produce their own sustainable energy or undertake a large variety of other energy related activities. Due to the richness and diversity within the Dutch community energy sector sufficient examples of socio-technically innovative energy collectives can be found to study their innovation dynamics.

1.3. Local energy

Local energy is a focal concept in this research. This section operationalises what is meant by local energy in this thesis, and introduces the history of the Dutch community energy sector as well as its state today.

1.3.1. Defining local energy initiatives

Together, local energy initiatives are often labelled as the community energy sector. Neither academic researchers nor policy makers have a clear definition of the multi-faceted concept of community energy[1]. It has proven difficult come to a clear delineation of the field [3], because 'one of the most notable features [of the sector] is the diversity of forms associated

[1] The discussion of the concept community energy that follows in this section is a lightly adapted version of an unpublished section of my 2015 MSc thesis "Towards a methodology for the assessment of the social impacts of community-owned renewable energy projects: A wind of change for Shapinsay?" I wrote at the Radboud University.

with the term', encompassing 'different technologies and scales of deployment in a range of ownership structures and policy contexts, involving many actors and their various motivations' [8, p. 524]. Local energy projects range from off-grid micro-renewables on remote Scottish islands, to wind guilds in Denmark, to bio-energy villages in Germany, to small-scale behind the meter solar in Australia, distribution cooperatives in Canada, and are also taken up by communities outside the Western world [8].

Due to the large variation of local energy initiatives, Hicks and Ison state that a 'singular definition is unlikely to be possible or even useful' [8, p. 523]. However, particularly since funding and other policy support is involved, failing to set proper boundaries also poses a risk. On the one hand, a too narrow definition can constrain the community energy sector's adaptability to 'develop in contextually appropriate ways, sensitive to the needs and desires of local communities'[8, p. 523]. On the other hand, too broad a definition 'leaves openings for charlatans to take advantage of the community brand, when in reality the community element might be little reflected' '[8, p. 523].

To come to a delineation of local energy within this research, two descriptions that are often cited in the community energy literature have been used for conceptual guidance. They are those of Walker and Devine-Wright [3] and Seyfang et al. [4]. Both influential works do not set clear boundaries, but aim to progress the understanding of the distinctive "community" element of community energy.

Walker and Devine-Wright suggest that it is the 'processes' and 'outcomes' that differentiate community projects from commercial projects [3, p. 497]. Accordingly, the uniqueness of the sector would not be defined by the technology, but by the particular 'social arrangements through which a given technology, irrespective of its scale or cost, is being implemented and made useful' [3, p. 498]. Process refers to 'who a project is developed and run by, [and] who is involved and has influence' [3, p. 498]. Outcome is concerned with 'how the outcomes of a project are spatially and socially distributed – in other words, who the project is for; [and] who benefits particularly in economic or social terms' [3, p. 498]. They indicate that community projects are the projects that are open and participatory on the process dimension and local and collective on the outcomes dimension. Figure 1.1 shows three viewpoints on community energy resulting from different positions of projects along the process and outcome axes. Walker and Devine-Wright found that some see a project as community energy if local people participate (A), some when the benefits are distributed locally(B), and some are not really concerned with a precise definition as long as a project is somewhere in the circle of C.

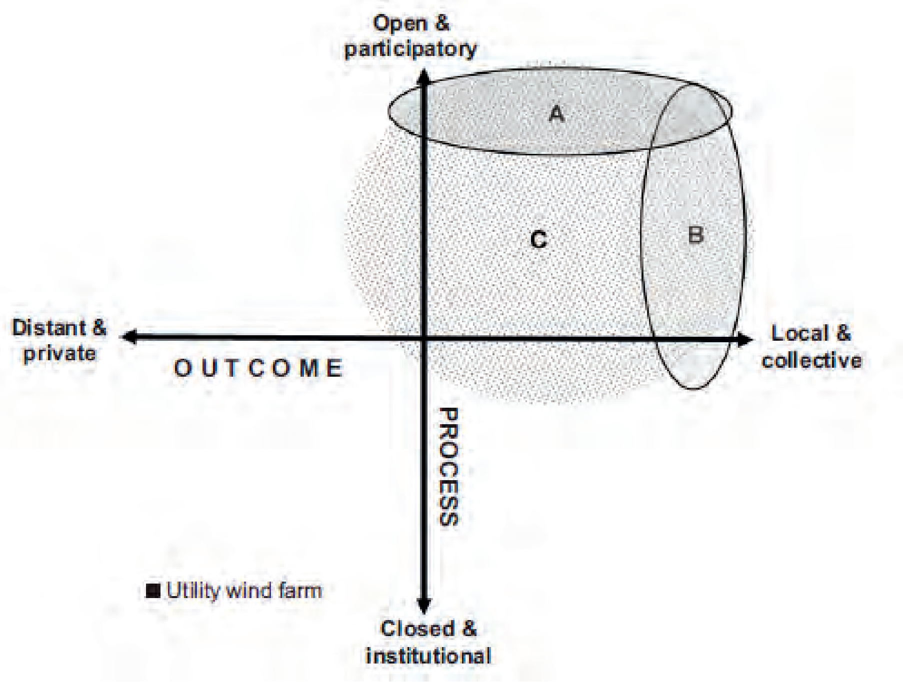

Figure 1.1: Understanding community energy in relation to process and outcomes dimension [3, p. 498].

Seyfang et al. also offer some grip on the slippery concept. Following Walker and Devine-Wright's lead, they point to the process and outcome dimensions of community energy, defining the sector to include projects 'where communities (of place or interest) exhibit a high degree of ownership and control, [and are] benefiting collectively from the outcomes' [4, p. 978].

Thus, analysis of the definitions of Walker and Devine-Wright and Seyfang et al. suggests that projects within the community energy sector are characterised by a degree of local and/or collective ownership and control (1), an extent of an open and participatory process (2), and local and/or collective benefits (3). A combination of the first aspect and at least one of the other two aspects is taken as the delineation of community energy in this thesis. This delineation closely resembles the C sphere in figure 1.1.

It is common to describe the local energy movement as the community energy sector and this research will do so as well. Yet, a deliberate choice has been made in this thesis to refer to the initiatives themselves as local energy initiatives and not community energy initiatives.

This decision has been made because the term community energy embodies 'implications and assumptions about the nature and quality of relationships between people and organisations' that are part of the community [24, p. 2655]. Especially within the contemporary discursive politics of governance, the community label is 'much used' and 'readily attached' to projects and policies to give them a warm glow and increase public support [24, p. 2657]. Also, within academia such positive assumptions are part and parcel of the community energy discourse.

Walker et al recognise that such narratives and claims about amongst others openness, inclusivity, and distributional justice 'are clearly predicated on the basis that communities can and do exist, in an unproblematic form and within many of the positive qualities with which they are readily associated' [24, p. 2657]. However, during their research the authors found that 'communities' were not always experienced as places where people are 'willing to support and work for the common welfare and good', and where 'people live together in harmony with different cultures and interests' [24, p. 2657]. More sceptical views on community showed that people felt that communities either 'are not really existing', or were not as inclusive as they might seem. Whilst appearing inclusive, a community was also found to be potentially 'deeply exclusionary' and 'marginalising those who are seen as not fitting' [24, p. 2657]. Therefore, community energy researchers should ask themselves who the community is, how inclusive it is, how it is involved in a community energy project, and how it benefits [25, p. 3].

Furthermore, when addressing communities of place, it is important not to assume that communities and places necessarily coincide [26, p. 337]. There can be 'multiple overlapping communities in a place and extended and constructed communities of interest that transcend physical delineations' [24, p. 2657]. Given these observations, it is important that a researcher critically asks him- or herself what the community is.

Hence, while recognising the potential and the promise of community energy projects to deliver various local benefits, the more neutral term local energy initiatives has been used. This term stresses locality, which is the most important element in this research as it looks into the innovativeness and transformative potential of local energy initiatives that operate and therefore, embed energy technologies in their own living environment. As a result, this means that the focus is on civic energy communities that are bound to a geographic community.

It is still recognised that energy initiatives with a local basis do in certain cases act supra-locally too.

1.3.2. A brief history of Dutch community energy

The documented history of community energy within the academic research community comprises developments from the 1980s onwards[23], [27]–[29]. Oteman et al. gives a comprehensive overview describing four partly overlapping waves [27], which we here use to provide a brief overview of the Netherlands' history with local and collective energy provision.

They explain how the seedbed for the first wave lies in the 1970s, when the oil crises and anti-nuclear protests challenged the national government's approach to energy. Dissatisfaction arose because national energy policy depended on import and focused on economic interests only. The first wave that developed at this time consists of twenty-five wind projects that were developed in the 1980s and 1990s. This wave was enabled by a legal change that allowed for decentral access to the grid to break regional monopolies, and later also the 1989 Electricity Act, which obliged energy suppliers to buy decentrally produced electricity for a standard price and guaranteed grid access. Some of these organisations, such as the Windvogel and Noordenwind, are still active and help starting initiatives with financing or advice.

After this wave, came a wave of nine Frysian village turbines, that arose under the same institutional conditions as the earlier wind cooperatives. The Frysian villages built a discourse coalition with provincial and municipal governments based on community revitalization. Based on this, the province made resources available that convinced local banks to provide loans. These village organisations also benefited from tightly-knit communities where people know and trust each other.

When the energy market liberalized between 1998 and 2004, few local initiatives developed because of the instability and unpredictability of the energy system. This third wave includes the pioneers in the liberalized market at the time that the Dutch government had embraced a transition to RE as a policy goal, but followed a broad and inconsistent approach. This approach was characterized by series of experiments, subsidies, pilot projects and policy platforms. It was a hostile climate for energy initiatives as the liberalized market was still a new territory, the investment climate uncertain, and policies changed rapidly.

Yet, climate change gained legitimacy through amongst others influential popular scientific documentaries and IPCC reports. In the period from 2006-2009 a new wave of local energy initiatives emerged inspired by the energy sustainability activities of NGOs and initiatives from fields such as neighbourhood development, housing construction and existing collaborations between farmers and citizens. These initiatives had a broad focus and a local approach. They opted for low risk and relatively simple projects that could yield short-term visible results, including resale of green electricity and collective purchase of privately-owned solar panels and information provision on energy saving and production. Enabling factors were the 2008 net metering regulation that allowed household energy producers to deduct the energy they produced that from their energy bill, and the dropping price of solar panels.

The fourth wave consists of the current boom of local energy initiatives from 40 in 2009 to over 500 today, and is still ongoing. Inspired by the pioneers from the third wave, this take off mainly started through emulation of the third wave's new activity: collective purchase of solar panels. Especially, during the economic crisis, solar panels were seen as an investment that would save money in the long run. Like the third wave these "follower" initiatives have a broad range of motivations ranging from environmental, to economic and societal.

From 2010 on, the movement started to grown and mature. It increasingly extended its network and professionalized. Two important financial support mechanisms have been playing a key enabling role. The 2013 postal code rose scheme enables small-scale users who are located in a pre-defined area around the collective production installation to get restitution of energy tax. Energy initiatives interested in developing larger energy projects can opt for the more secure but highly competitive SDE+ subsidy, which was introduced in 2011 and is targeted at companies.

1.3.3. Dutch community energy today

Over the last few years, community energy in the Netherlands has been experiencing a rapid growth. The Dutch local energy monitor shows that during the last four years number of community energy initiatives in the Netherlands has doubled from 248 initiatives in 2015 to 582 in 2019 [29]. During this period, the capacity of the most popular technologies-- solar and wind-- grew from 83,4 MW to 311,2 MW. The electricity use of a quarter million households is now supplied by these initiatives, and the movement has been estimated to have around 85.000 members and participants.

The most common legal entity for an energy initiative in the Netherlands is a cooperative association with excluded liability (*in Dutch: coöperatieve vereniging U.A.*). The members set out the goals of the cooperative association in the memorandum and articles of association, and govern the cooperative via a one member one vote system. Excluded liability means that only the capital brought in can be lost, and the members have no further liability. A few initiatives are incorporated as a charitable foundation and use this entity as an umbrella organization that owns the cooperatives or private limited companies set up for specific projects.

When it comes to the activities of the Dutch cooperatives, many of them started out with energy saving and energy production projects. In energy savings projects, cooperatives offer advice on energy saving behaviour and technologies, and facilitate their implementation (e.g. through setting up collective purchase deals, promoting smart meters or LED lights, or organizing a saving competition). This requires less time, resources and expertise than the development of an energy production installation, creates visibility for a starting cooperative, and every kWh that has been saved does not have to be generated. The second main activity of most cooperatives in the Netherlands is energy production. When it comes to production, 80% of the cooperatives develop solar, 24% wind, and a small but growing number (5) produces and manages heat (e.g. from biomass, geo-thermal sources, or heat from industry, sewerage or surface water)[29]. A third type of activity is support of and collaboration with local and regional policy makers regarding policies such as gas-free neighbourhoods and regional energy strategies. Last but not least, energy cooperatives exceedingly expand their activities and work on energy sustainability from a more holistic and integrative perspective, branching out to amongst others shared automobility, green gas, hydrogen, storage, smart grid solutions and flexibility services. In doing so, they act as partners or initiators in innovation projects with knowledge institutions, DSOs, companies, and funders, and use their living environment as a testing bed for new innovations, such as new technologies or technological configurations, or business models [29], [30]. Thereby, the local energy movement may start or enhance new developments [29].

The community energy sector in the Netherlands is not only growing but also professionalizing, and building and extending an own network of support platforms, supra local umbrella organisations, intermediary organisations, and a lobby organisation. The most important actors in this network are:

- HIER opgewekt: national knowledge platform facilitating a learning community;
- EnergieSamen: lobby organization at national level for local energy;
- Cooperative energy companies: VanOns, AGEM, and om I nieuwe energie buy energy

from local cooperatives and act as supplier. Furthermore, they sometimes take on administrative tasks and function as back-office. Before, the cooperative energy companies were founded these tasks outsourced to regular energy companies, and some energy initiatives still use their services;

- Regional umbrella organisations of cooperatives: cooperatives of cooperatives, which are province-based such as Groninger Energiekoepel, Ús Koöperaasje and Drentse Kei;
- Nature and environment federations take on a supportive role in many provinces;
- Energy cooperatives increasingly partner up and collaborate with DSOs and other established energy sector players;
- The municipalities and provincial governments are also part of the network. They provide knowledge, permits and sometimes subsidies. By times, the energy initiatives provide services to the municipality as well, such as staffing an energy information office. Some energy cooperatives also managed to get European Union subsidies for their projects (as part of a consortium).

Dutch local energy initiatives have greatly benefited from financial support schemes for RE. Main supportive policies are: net metering (salderen), the regulation lowered tariff (postal code rose regulation), and the stimulation regulation sustainable energy ++ (SDE++) feed in tariff. Here is explained how these support schemes work as well as which percentage of cooperatives is using these.

- Net metering: the kWhs renewable energy supplied to the grid can be subtracted from the kWhs on the energy bill. Can only be used when the installation is connected to one’s own electricity meter (household level incentive). An example of use in the cooperative movement is a cooperative that helps arranging solar panels for renters, who then use the net metering policy. Twelve percent of energy initiatives uses this. From 2023, the energy that can be net metered will gradually be reduced, as the government assumes that the solar energy will be competitive enough due to the decreased price of the panels.

- Regulation lowered tariff (postal code rose regulation): This regulation enables restitution of the energy tax during 15 years for user-participants that live in the socalled postal code rose area around the production installation (see figure 1.2). The administrative centre of the postal code rose can also be located in one of the leaves to increase the number of potential participants. The regulation has been revised, and entered a new phase in 2021 (structured more like a feed-in tariff now). This resulted in insecurity, which made that some energy initiatives rather waited because they were unsure about their ability to realise their project before the revision. 60% uses this regulation.

Figure 1.2: Postal code rose area in which a project can look for participants[31]. The dark red area is the administrative centre, where the installation is often located, and the lighter areas are the leaves.

- SDE++: This is a biyearly allocated feed-in tariff. There is a fixed budget for several renewable energy categories (technology-based). The local energy initiatives and other project developers send in a bid for the subsidy they require and the lowest bids will be granted the subsidy. This subsidy is fairly competitive and the auction is always heavily oversubscribed. 26% uses this regulation.

Also non-financial supportive policies exist. An important one is a measure supportive of local ownership. The local energy movement successfully lobbied for a target of 50% local ownership of renewables for 2030 to be taken up in the 2019 Climate Agreement. Currently, the implementation of the Climate Agreement takes place via an area-based approach with regional energy strategies. Local energy initiatives are seen as important stakeholders and are actively involved in the co-design of these strategies with other stakeholders.

Furthermore, the executive order 'experiments decentralized, sustainable electricity production' enabled derogation from certain articles of the Electricity Act on experimental basis (case by case) to facilitate grid balancing. Applications could be made from 2015-2018, and it was only for energy cooperatives and owners' associations. In the proposed but cancelled next round, more stakeholders could have proposed a project.

Also on the provincial level various supportive policies exists. For example, in Groningen the provincial government offers a subsidy for start-up costs.

To sum up, local energy specific and general renewable energy policies are supportive of the growth of the local energy movement. Due to the development of the movement, community energy reached a stage at which it can function as stakeholder that is part of energy policy design and has had a limited but demonstrable positive impact on the creation of supportive policy.

1.4. Socio-technical innovation

The second focal concept in this research is socio-technical innovation. Doci et al. present describe how civic engagement with RE can be understood as an intricate system of social and technological development[15]. When civil society actors set up collective RE projects, they create spaces for societal experimentation with new forms of energy consumption and production that have a potential for widespread participation and a focus on social learning[32]. Local energy initiatives develop new forms of organisation and collaboration as well as new technological constellations. Hence, socio-technical innovation was taken as a conceptual starting point in this thesis to research the transformative potential of their innovative activities.

Socio-technical innovation can be defined as a process of simultaneous and interwoven social and technological innovation. These two types of novelty are understood to co-evolve within sustainability transitions literature [14], [33], [34]. Social innovations can incentivise technological innovation, and technological innovation can simultaneously affect social organisation [35], [36].

While acknowledging the impossibility and undesirability of attempting to either fully or cleanly separate the social from the technical, the two dimensions of socio-technical innovation are briefly introduced here. Starting with the social dimension, social innovativeness can be understood as a new way of doing business, while pursuing a social goal [37]. In the energy field, it entails new ways of organising energy production and consumption being set in motion by heterogeneous and changing groups experimenting with new modes of social organisation, such as novel business models and financing schemes. Technological innovativeness, on the other hand, can be seen as the array of technological change ranging from the diffusion of novel technologies, to incremental changes in processes, product reformulation, product substitution and the development of new processes [38]. Technological innovation typically entails the emergence of social innovation, such as new practices, generic rules and lessons. However, social innovation does not necessarily require the presence of technological innovations (e.g. bio-agricultural communities, community development) [15]. Thus, social and technological innovations are often closely connected, and social innovation is not just a requirement, side-effect or result of technological innovation.

These definitions of social and technical innovativeness have been used to further operationalise socio-technical innovation by local energy initiatives for this research. Initiatives can differ in social and technological innovativeness. Initiatives can be highly technologically innovative but limitedly socially innovative, vice versa, or can be innovative in both or none of the dimensions. The initiatives that are focused on in this research range from modestly to highly technologically and socially innovative.

1.5. Aspects influencing socio-technical innovation by local energy initiatives

To narrow down the research and define the scope for the empirical chapters of the thesis, three interlinked, focal elements were identified from the literature that are important to further understand socio-technical innovation by local energy initiatives: technological configurations; policies and regulations; and multi-stakeholder processes. The remainder of this section will discuss these elements as they have been used to underpin the choice for the sub-questions of the thesis.

1

1.5.1. Technological configurations

Much of the influential early work on community energy used an innovation studies approach and explored whether or not community energy had potential to facilitate regime change through its role as embedder of new energy technologies via innovative socio-technical configurations. Research tended to focus on the upcoming movement's potential to cause regime change through becoming a dominant player in the energy regime[6], [15], [39].

However, less attention has been payed to other ways technical experimentation by local energy initiatives can potentially contribute to energy transition. This part of the thesis continues on work such as Verkade & Höffken[40] and De Vries et al.[41], who look at how local energy initiatives or their members shape and interact with novel technological configurations.

Verkade and Höffken looked at the piloting of an online platform supporting the use of community-generated solar electricity by members of a cooperative. They found that the interlinked nature of the energy consumption practices can prevent the monitoring insights from changing use patterns. The members of the local energy initiative helped the development of smart software by enabling research on domestic users of energy technologies and their behaviours.

De Vries et al. focused on novel activities in the community energy sector and framed them as configurational user innovations, i.e. user-designed arrangements of loosely related sets of components. They show how innovative energy initiatives combine off-the-shelf technologies with novel technical and non-technical ideas, rather than try to make clear-cut changes to existing devices. Their work shows how the value of the innovations, referred to as tinkering with technology, lies in how initiatives naturally embed these technologies into their wider business, social and community context. Other authors also point to how such configurational work with novel technologies leads to new business models, collaborations, and place-based solutions for local energy transition that are more aligned with local interests (e.g. [15], [42]–[44]).

Conceptualising innovations as configured networks of socio-technical elements, paves the way for analyzing the development process of socio-technical innovations, instead of only seeing them as an outcome that can or cannot be upscaled. Planned and unplanned impacts on the energy transition can be better traced when framing innovation as a configurational process of networking.

These understudied networking processes are particularly interesting, because energy initiatives are often voluntary organizations, have limited resources and have few existing structures to guide their innovative endeavors. In addition, innovating requires experimentation and creates uncertainty, which exerts pressure on the relationships that need to be formed and maintained for a working configuration.

Hence, the first sub-question central in this thesis is how do local energy initiatives develop and implement ***innovative technological configurations***?

1.5.2. Policies and regulations

Enabling regulation and stimulating policies have been very important for community energy to take off [23], [45]. It creates the institutional space for collective, civic entrepreneurship in the energy sector.

As mentioned earlier, in the Netherlands the first opportunities were created by the national government in the 1980s by opening up the grid to decentral access, and through the 1989 Electricity Act which obligated energy suppliers to buy decentrally produced electricity for a standard price and guaranteed grid access[27]. Later, energy transition incentives such as feed-in tariffs and other RE subsidies helped the movement expand[45]. Even policies specifically aimed at the community energy movement were developed, such as the postal code rose incentive[46] and an experimentation decree for piloting more integrated grid management[47].

Not only national policy and regulations are important for the community energy movement. Municipal and regional level policy is also important in governing the transition to a more decentralized and locally embedded energy transition [48]. Active civic engagement with the energy transition requires policy innovation to support this at the local level. Hoppe et al. show how the success of local energy initiatives is to a great extent influenced by close interaction and mutual trust between local government and representatives of the local communities. Such a working relationship can be established through proper process management and strategic, responsive, community serving, and reflexive leadership[48].

At the European Union level, local energy is also on the agenda and specific policy has been made to stimulate its development. The EU's ambition is to establish an 'Energy Union' that empowers citizens to actively interact with the energy market as self-consumers or prosumers[49]. The Clean Energy for All Europeans Legislative Package (CEP) provides a legal framework that will not just help the EU meet its 2030 climate and energy targets. It also requires Member States to ensure certain rights for "renewable energy communities" and " citizen energy communities" that help level the playing field and stimulate their development [50]. This can create opportunities for local energy initiatives but how this legislation will exactly be transposed remains to be seen.

Hence, policy and regulations at the local, national and international level determine the institutional space, and, thereby, what roles initiatives can legally enact when it comes to energy provision. Yet, previous experiences with novel regulations show that merely having a legal space to innovate does not mean new activities can be easily undertaken with success [46], [47], [51]. New regulations are not always sufficiently aligned with existing regulations, can be complex, or limited in usefulness due to practical constraints such as the lack of a feasible business model. More insight in how energy policy can better facilitate bottom-up energy innovation requires further research.

Therefore, the second sub-question central in this thesis is what can be learnt about constraints and opportunities of new and existing energy ***regulations and policies*** with regard to local energy initiatives' bottom-up experimentation.

1.5.3. Multi-stakeholder processes

Embedding of and experimentation with RE technologies requires process innovation and new collaborations[15]. To realise their increasingly complex projects, energy initiatives collaborate within the cooperative energy sector, but also reach out to other actors.

Within the cooperative sector, local energy initiatives learn from each other. Furthermore, they institutionalised learning and knowledge sharing by setting up regional umbrellas, a national platform, and a lobby organization. This multi-leveled system makes for cross-scale interactions where insight flows bi-directionally[43]. Also, the cooperative energy supply companies, and supportive intermediaries such as certain environmental NGOs, can be counted as part of this growing network that aims to stimulate the growth of the niche for local energy.

In order to make possible or extend their activities, cooperatives also forge alliances with actors outside the cooperative movement. Some cooperate with incumbent or recently founded energy companies. They collaborate by outsourcing some of their activities (e.g. back office for administration, supply, and billing). While the initiatives in principle have a let's do it ourselves attitude [11] and are keen on their grassroots values, they can overcome hurdles such as lack of financing, marketing, professionalization, and legal constraints by collaborating with commercial parties and creating hybrid business models [44]. In other projects, such as under the experimentation decree, they also cooperate with technology developers, DSOs and knowledge institutions[47]. Last but not least, energy initiatives look for synergy with local businesses, associations, and other organisations in realising their projects[43].

Not only do local energy initiatives need to include the ones they need for developing their project, but they should also not forget to engage the ones impacted by their projects (human and non-human). As raised earlier while problematizing the term community energy, there can be multiple groups with different interests and values in one place[52]. More research on how prospective local owners of energy installations can include other local stakeholders, such as neighbours and representatives of nature and landscape NGOs, would add to the literature on social acceptance of local energy projects[53]. Especially, now the impact of renewable energy on the landscape is increasing as the energy transition progresses.

Hence, because of the increasing complexity of the projects of energy initiatives and the increase of the landscape impact of RE, multi-stakeholder processes are becoming even more important. The third sub-question in this thesis is how innovative ***multi-stakeholder processes*** can contribute to acceptable embedding of locally-owned energy technologies.

The aspects technological configurations, regulations and multi-stakeholder processes are central to better understanding roles local energy initiatives can fulfill by experimenting with socio-technical energy innovation. Figure 1.3 shows how they relate to each other. This figure provides a simplified representation of the ways in which they are related. Central to the socio-technical innovation process are the development of novel RE energy technologies and the processes of embedment of these technologies through interaction and collaboration with actors in and beyond the local energy initiative. The roles that a local energy initiative can play in the energy transition are heavily influenced by the regulations and policies, and these delineate the institutional space for innovation.

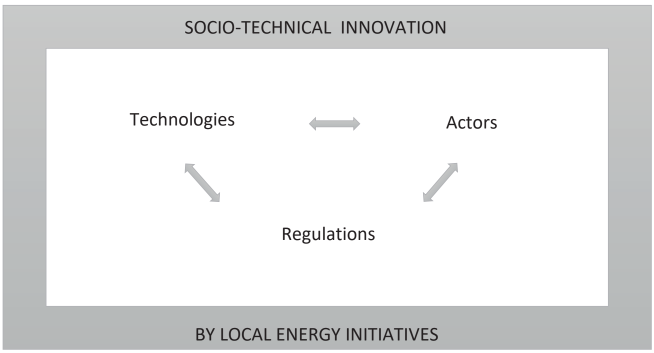

Figure 1.3: Three interdependent aspects influencing socio-technical innovation by local energy initiatives.

1.5.4. Sub-questions

To be able to answer the main research question about the roles local energy initiatives can play by experimenting with socio-technical energy innovations, I came to four sub-questions. The first three sub-questions are identified based on the previously introduced and interrelated aspects of socio-technical innovation by local energy initiatives. The fourth sub-question takes a historical stance. This sub-question aims to gain insight into the interplay of technological development, the actor-constellation, and regulations during another period in time. This will be discussed in relation to today's involvement of energy initiatives in the transition.

So, the four sub-questions addressed in this thesis are:

1 How can local energy initiatives develop and implement ***innovative technological configurations*** by creating a supportive network? (CH2)
2 What can be learned about supporting local energy innovation from **regulatory experimentation**? (CH3)
3 How do value-sensitive **multi-stakeholder processes** contribute to acceptable embedding of locally-owned energy technologies? (CH4)
4 How did **historical** energy initiatives contribute to socio-technical innovation during the adoption of electricity technology, and how was this influenced by the interplay between technologies, actors, and regulations? (CH5)

1.6. Methodology

This section introduces the case-based approach followed in this thesis and explains the case selection process. More detailed information on methodology can be found in each of the empirical chapters.

1.6.1. Case-based approach

Data for the empirical chapters were collected through a case-based approach. One chapter focuses on historical cases and the three others on contemporary cases. All of these studies cover multiple case studies (2-4) and describe socio-technical innovations over a time period ranging from a couple of years to a few decades in the historical study.

By using a case-based approach, a phenomenon can be investigated in relation to its context. That way contextual conditions that might be highly pertinent can be taken into account[54].The strength of the case study is that it can provide a rich and in-depth understanding due to its ability to deal with a full variety of evidence, such as documents, artifacts, interviews, and observations[54].

The case-based approach allows to add to knowledge by analyzing, understanding, and then to an extent generalizing from the cases [55]. This should not mistakenly be interpreted as nomothetical universalizing, but as developing an understanding with explanatory power that goes beyond the unique instance of the case as object of inquiry.

Explanatory power in case study research is ascribed to the interplay of a plurality of events, factors, mechanisms, and contributors. Therefore, it is important to recognize that different contexts result in different outcomes, and that different mechanisms even may produce similar outcomes[55]. Hence, the applicability of the findings and the limitations to this applicability need to be precisely specified based on the characteristics that have been used as selection criteria. Thus, the characteristics of the case and the extent to which these are similar to other cases are in direct relation with the range of applicability.

1.6.2. Case selection process

Representativity of the Dutch local energy movement has not been used in this thesis to select the cases. In all chapters the cases have been selected for information-oriented sampling to offer insight in specific innovation dynamics of local energy initiatives. These cases are specifically chosen for their explanatory power due to interesting, unusual or particularly revealing characteristics[56].

For this thesis about innovation dynamics, the average local energy initiative, or typical case is generally not the richest in information since few energy initiatives are highly innovative in terms of social-technical characteristics. The cases in the empirical chapters were selected based on extraordinarily high socio-technical innovativeness and represent in that sense extreme cases with respect to other local energy initiatives.

The identification of innovative local energy initiatives for the chapters was an iterative and multi-phased process. The interest was in recent innovation projects in the Dutch community energy sector. It was positive for this research that the Dutch community energy movement has significantly grown and developed over time, and started experimenting more and more with new technologies and configurations, processes and collaborations, and regulations and policies.

At the start of this research, identifying recent innovative projects that are high in social and technological innovativeness was rather difficult as such projects were often not announced online, especially if they were not operational yet. If they were announced online, they were often already part of a consortium of researchers and technological developers, and, due to the limited time these initiatives have to engage with researchers, it was not always possible to include their projects. Hence, it was critical to reach out to contacts in the several professional networks available within this research project to identify case studies.

1.7. Outline

This thesis explores the three previously identified aspects of socio-technical innovation by local energy initiatives: technologies and configurations, multi-stakeholder process and policies and regulation. Innovation dynamics as observed during the current transition to renewable energy (CH2-4), and the electrification period (CH5) are both covered.

In chapter 2, the spotlight is on the design of new technologies and socio-technical configurations by energy initiatives. It explores how they can develop technological innovations by bringing together local actors and creating a fit with local circumstances. Grounded in actor network theory (ANT) and structured by concepts from Callon's sociology of translation, two technologically innovative projects were studied. Through document analysis and interviews was researched how these initiatives developed their innovations by forming networks of social, material, and discursive elements.

In chapter 3, the importance of new regulations and policies for enabling socio-technical innovation by local energy initiatives has a central position. It analyses the Dutch executive order 'experiments decentralized, sustainable electricity production' (EDSEP) that functions as a regulatory sandbox and invites homeowners' associations and energy cooperatives to propose projects that are prohibited by extant regulation. Local experimenters can after approval of their project plan derogate from the Electricity Act, and, for instance, organise peer-to-peer supply and determine their own tariffs for energy transport in order to localize, democratize, and decentralize energy provision. Theoretically, this chapter is rooted in institutional economics and uses Ostrom's concept of polycentricity to study the dynamics between actors that are involved in and engaging with the participatory experiments. Empirically, four approved EDSEP experiments were examined through interviews and document analysis.

In chapter 4, new processes and collaborations between local energy developers and other local stakeholders have the centre stage. It explores how local energy initiatives, in this chapter farmers' initiatives, can improve the acceptability of their energy projects through process innovation brought about via more inclusive planning processes. The emphasis in this chapter is on the potential for broad representation of local stakeholders' values in the project design process, including amongst others business model, choice for the technology, and placement. The study analyses how the initiators of the projects and the other stakeholders attempted to resolve or ameliorate inter- and intra-value conflicts regarding liveability, economy, landscape and nature. Informed by value sensitive design literature, two contrasting cases in the Dutch province of Groningen were analysed: the implementation of mini-turbines in a national landscape, and a large-scale multi MW wind project in an industrialized area close to a World Heritage nature reserve.

Chapter 5 offers a historical perspective on socio-technical innovation by Dutch energy cooperatives, and discusses the emergence of electricity cooperatives during the electrification in the early 20th century. This chapter brings a nearly forgotten, and largely unknown part of the early history of Dutch cooperative electricity back from the margins of historical work on electrification: the emergence of electricity cooperatives in the early 20th century. By using the concept proto-regime from the multi-level perspective on socio-technical transitions, the role of these electrification cooperatives during the development of electricity from niche market to a regime with its own actor constellations, rules, and material and technical elements is studied. Through this analysis is contributed to an understanding of niches as heterogeneous innovation environments where diffusion and embedding of niche technologies can take place at different paces and in distinctive ways across localities. The results from this chapter are used in the conclusion chapter to compare to the development of the current community energy movement and its role within the energy transition to sustainable energy.

Finally, chapter 6 concludes this thesis. It revisits the findings from the empirical chapters and discusses the transformative potential of local energy initiatives as innovators in the transition to a renewables-based energy system. Besides addressing the main research question, the chapter contains a theoretical and methodological reflection, comparison between the electrification niche and current community energy niche, and recommendations and suggestions for future research.

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