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Editorial

New Pathways for Community Energy and Storage

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1. Introduction

Worldwide, the energy landscape is changing. Energy transition has now been on the agenda of most of the governments, companies, non-governmental organizations, investors and other stakeholders around the world. It is not only focused on decarbonisation, but also on technology improvements and integration, policies, business models and citizens' engagement. Local communities are increasingly taking active roles and emerging as new actors in the energy system. In some European countries, in particular Denmark, Germany, the Netherlands and the United Kingdom, local energy communities are already considered important stakeholders in the energy system. For example, many local energy initiatives own or manage solar panels, wind turbines, micro-grids or large scale integrated systems collectively. The central role of citizens is also reflected in recent EU policy. The clean energy for all package of the European Union, through the 2018 recast of the European Renewable Energy Directive (RED II) and the 2019 recast of the Electricity Market Directive (EMD II), define and promote renewable energy communities and citizen energy communities, respectively.

At the same time, energy storage has also become one of the key building blocks of the energy transition because of the growing need to balance the supply and demand mismatch, resulting from more decentralized and variable renewable energy production, in particular by wind turbines and PV panels as well as increasing electrification of end-use sectors such as transport and heating. Therefore, both community energy and storage are related to the move from a centralized to a more decentralized and democratized energy system, in which parts of production, delivery and management take place at the local level through active citizens and local stakeholders' engagement. The demand for new technical systems that combine generation and storage at the local level will increase. Accordingly, roles and responsibilities are also shifting and there is an increasing need for new revenue models, organizational forms, decision-making processes as well as partnerships between private partners, governments, and civil society organizations. Accordingly, new and innovative socio-technological energy and storage configurations are emerging at local and regional levels.

This broadening of the transition theme prompted the Universities of Groningen and Twente to organize an international conference on New Pathways for Community Energy and Storage from 6 to 7 June 2019 in Groningen. In this editorial, we summarize the different topics covered in this international conference as well as the papers of this follow-up Special Issue on the same topic. Both the Special Issue and the conference aimed to address important developments and challenges related to local energy transitions and the role of community energy and energy storage therein.

All contributions to this issue focus on the role of energy communities, energy storage, or both. Nine contributions investigate the potential and constraints of energy cooperatives, citizens energy and community energy [1–9]. Three contributions discuss both community energy and local energy storage [10–12]. Some of them take individual households as the point of analysis [10], while others explicitly discuss national [2–5,11] or European Union (EU) governance [6–9], or the issues of energy justice and social-technological dynamics [2,3,12]. Approaches vary from modelling [13,14] to theory development [1] and empirical studies, including case studies and surveys. Two papers explore the way agent-based modelling can be used for local storage [13,14]. Broadly, the articles published in this Special Issue can be categorized into three themes: firstly, articles that focus on the understanding of the community energy dynamics; secondly, articles that study the specific new energy element in communities: energy storage; and thirdly, articles that address the institutional aspects of the interface between community energy and broader society (policy, tools, ethics, impacts, etc.).

To put the contributions to this Special Issue and the conference in perspective, the rest of this editorial article is organized based on these three broad categories, namely, community energy dynamics (Section 2); modelling, implementation and use of community energy storage (Section 3); and institutional aspects of community energy and storage (Section 4). Each section starts with a brief introduction to the relevant articles in the Special Issue. In Section 2 on community energy dynamics, we will consider developments, impact and definitions of community energy. In Section 3, we will describe developments, characteristics and perspectives of community energy storage. Section 4 delves into options for new types of coordination and the need to take into account energy justice. Eventually, we formulate some thoughts on new pathways in community energy and storage research and policy, and required configurations, in Section 5.

2. Community Energy Dynamics

Four of the articles in this Special Issue focus on community energy dynamics.

Wagemans, Scholl and Vasseur (2019) study the governance role of local renewable energy cooperatives in facilitating the energy transition [9]. The authors claim that energy cooperatives may contribute to the current decentralization movement and to a "just energy transition." Based on their empirical work in the Dutch province of Limburg, the authors identify five key governance roles that cooperatives take up in the facilitation of the energy transition: (1) mobilizing the public, (2) brokering between government and citizens, (3) providing context specific knowledge and expertise, (4) initiating accepted change and (5) proffering the integration of sustainability.

While it is possible and meaningful to conduct in-depth studies on community energy and various functions of long-standing energy cooperatives in countries such as Denmark and Germany, development has so far been less advanced in other countries. Candelise and Ruggieri (2020) focus on the development of community energy in Italy [4]. The authors review Italian initiatives and present three case studies to explore conditions for development and success of community energy initiatives. The authors found that small initiatives are largely dependent on national photovoltaics policy support. Only larger initiatives that were able to operate at a national scale, developing multiple projects and differentiating their activities, have managed to continue growing at the time of discontinuity of policy support and contraction of the national renewable energy market.

Gorroño-Albizu (2020) explores the options for new types of consumer ownership at the national level and introduces new types of smart energy systems to integrate several energy sectors [5]. She studied the ability of cross-sector consumer ownership at different locations in the power distribution system in Denmark. The results indicate that distant and local cross-sector integration will be necessary to reduce overinvestments in the grid. In addition, consumer co-ownership of wind turbines and power-to-heat units in district heating systems may provide advantages over separate common ownership regarding local acceptance and attractiveness of investments. This requires, however, improvements of the current institutional incentive system in Denmark. In particular, the current EU policy-based regulation that dictates unbundling of energy sectors/services could be an impediment to implementing cross-sector ownership solutions, such as the one presented in this study, but also in other EU countries.

One of the papers explicitly stated the need for new theoretical frames to analyze and understand the role of energy communities. Gregg et al. (2020) aimed to synthesize aspects of sustainable transition theories with social movement theory to gain insights into how what they call "collective action initiatives" mobilize to bring about niche-regime change in the context of the sustainable energy transition [1]. The authors discuss how these energy initiatives can be described within both sustainability transition theories, such as the Multi-Level Perspective, and Strategic Niche Management, and Social Movement Theory, which focusses on how social movements share interests, give shape to the identity of their organization, and mobilize resources. Making use of both traditions, the authors adapt and apply a mobilization model to gain insight into the dimensions of mobilization and upscaling of these initiatives. By doing so, they show that their expanding role is a function of their power acquisition through mobilization processes.

As can be seen in above mentioned paper, one of the characteristics of the energy transition is its democratization through the recognition of the role that citizens, citizens' groups or communities play or might play in the decision-making, design and management of energy. In our view, the involvement of communities in future energy systems is important because it leads to a more effective, democratic and inclusive energy transformation, it stimulates decentralized energy systems and it leads to more efficient generation that is closer to the points of consumption, thus leading to fewer networks, and may provide energy at lower prices than their commercial counterparts.

In addition, energy cooperatives may play a significant role in the production of renewable energy, sharing new types of socio-technological innovation, acceptance and acceleration of this transition or making it more just and democratic.

3. Modelling, Implementation and Use of Community Energy Storage

Five of the articles in this Special Issue focus on community energy storage.

Hoffmann and Mohaupt focus on the perspectives of consumers and residents in Germany on "community energy storage" [11]. They found owners of photovoltaics systems to be receptive to the idea of community energy storage because they assume this is more resource- and cost-efficient than residential storage. Owners ask for professionally managed operation and maintenance, as well as transparency of operation and management. They fear potential disadvantages such as increased coordination with neighbors, increased data security risks and fear that other participants treat common acquisitions less carefully. The authors think that abating these perceived disadvantages can help to increase the acceptance of community energy storage. The owners are also interested in monitoring, energy management and other services, as part of the storage system. It is suggested that multi-use storage systems are developed, including various ancillary services for energy networks.

It is not the perception of energy technology by residents, but the impact of this type of technology on households that is central in the contribution of Kloppenburg, Smale and Verkade (2019) [10]. They discuss how residential energy storage technologies such as home batteries can enable householders to contribute to the energy transition, but also afford new roles and energy practices for householders. The authors regard energy systems as sociotechnical configurations and use the term "mode" to understand and classify the different ways in which households use technology and give meaning to it. Their results point to five emerging storage modes in which householders can play a role: individual energy autonomy; local energy community; smart grid integration; virtual energy community; and electricity market integration. They argue that, for householders, these storage modes facilitate new energy practices such as providing grid services, trading, self-consumption, and sharing of energy. Several of the storage modes enable the formation of prosumer collectives but will change relationships with other actors in the energy system. The authors discuss how householders face new dependencies on information technologies and intermediary actors to organize the multi-directional energy flows which battery systems unleash. Because energy storage projects are currently provider-driven, they advocate giving more space to experiments with mixed modes of energy storage that both empower householders and communities in the pursuit of their own sustainability aspirations and serve the needs of emerging renewable energy-based energy systems.

Koirala, van Oost and van der Windt (2020) studied the interaction between energy technology development and societal actors, including engaged citizens [12]. They analyze the rise of two new storage technologies, the seasonal thermal storage Ecovat system and the sea salt battery of DrTen, and the way they were implemented by local energy cooperatives. The authors show how both technologies received support from governmental agencies, DSOs, universities, energy cooperatives and technology funders because of their sustainability and their ability to apply them at the local level for balancing of the grid. In practice, however, some unexpected problems arose. National regulations turned out to be financially disadvantageous for storage systems. In addition, it took a while to integrate the battery into the energy system. The possible side effects of the building of the Ecovat system caused more resistance of locals than expected. From local energy cooperatives, it asked a lot of effort to judge and take decisions on these types of new storage technologies. The authors conclude that socio-technical alignment of various actors and factors, human as well as material, national and local, is a key element in building new socio-technical configurations. During this process, new storage technologies, communities and embedded values are being developed and adapted.

Fouladvand, Mouter, Ghorbani and Herder (2020) developed an abstract agent-based model for local generation and distribution of thermal energy by community-driven initiatives [13]. These types of initiatives remain largely unaddressed in the literature, although thermal energy applications cover 75% of the total energy consumption in households and small businesses. The authors studied four factors that influence the formation and continuation of thermal energy communities: neighborhood size, minimum number of members required, satisfaction of households and number of drop-outs. Their modelling indicates correlations between this type of community formation and the percentage of households that joined, and with the satisfaction of households.

Mir Mohammadi Kooshknow, den Exter and Ruzzenenti (2020) argue that development of electricity storage systems is hindered by a lack of viable business models, as well as high levels of uncertainty in technological, economic, and institutional factors [14]. The authors discuss barriers to and uncertainties in the development of storage systems in the Netherlands, and provide a theoretical foundation for combining agent-based modeling and exploratory modeling analysis as a method to test and explore business models for electricity storage systems. The authors suggest using their agent-based model as foundation of detailed design and for testing electricity storage system business models in the Netherlands and worldwide.

As observed in these articles, there is an urgent need to find new, efficient and affordable ways to balance the supply and demand of energy. The power grid in western industrialized and urbanized countries is heavily burdened by all local and national initiatives for solar and wind energy, which increases the need for balancing. So far, however, it has turned out to be difficult to find appropriate solutions.

Despite the need to stimulate storage projects, many questions remain unanswered. What role storage may play in the balancing of the energy system, which forms of storage are promising, at what temporal and spatial scales, and how are they geared to existing systems? In addition, the way they are organized and by whom, and the distribution of costs and benefits are also open questions.

4. Institutional Aspects of Community Energy and Storage

Five of the articles in this Special Issue focus on institutional aspects.

Several authors studied the impact of legislation on citizens' energy and community energy. Horstink et al. (2020) investigated the implementation of the two new EU energy

Directives in nine EU countries [7]. The ambition of the European Union is to establish an "Energy Union" that is not just clean, but also fair and inclusive: citizens actively interact with the energy market, such as prosumers. Although prosumerism in relation to renewable energy sources has been growing for at least a decade, the two new EU Directives are intended to legitimize and facilitate its expansion. The authors identified several internal and external obstacles to the successful mainstreaming of renewable energy prosumerism, among them a mismatch of policies with the needs of different prosumer types, potential organizational weaknesses as well as slow progress in essential reforms such as decentralizing energy infrastructures.

Lowitzsch (2019) also takes the new EU legislation as a starting point [8]. He introduces consumer stock ownership plans (CSOPs) as the prototype business model for renewable energy cooperatives. Based on the analysis of 67 cases of consumer (co-) ownership, he demonstrates the importance of flexibility of business models to include heterogeneous co-investors. In Europe, this is needed, he thinks, for meeting the requirements of the new European Union energy Directives. In this paper, it is shown that CSOPs—designed to facilitate scalable investments in utilities—facilitate co-investments by municipalities, SMEs, plant engineers or energy suppliers. They may enable individuals, and also low-income households, to invest in renewable projects. Employing one bank loan instead of many micro loans, CSOPs reduce transaction costs and enable consumers to acquire productive capital, providing them with an additional source of income. The author stresses the importance of a holistic approach, including the governance and the technical side, for the acceptance of renewable energy cooperatives on the energy markets.

Because current legislation is one of the main hurdles for community energy, some countries started experiments with new legislation. van der Waal, Das and van der Schoor (2020) studied some Dutch examples of so called "regulatory sandboxes", participatory experimentation environments for exploring revision of energy law [3]. These sandboxes allow for a two-way regulatory dialogue between an experimenter and an approachable regulator to innovate regulation and enable new socio-technical arrangements. The authors looked at the way power roles and power relations changed during these experiments. They researched the Dutch executive order called "experiments decentralized, sustainable electricity production" that invites homeowners' associations and energy cooperatives to propose projects that are prohibited by extant regulation. Local experimenters can, for instance, organize peer-to-peer supply and determine their own tariffs for energy transport in order to localize, democratize, and decentralize energy provision. The authors use Ostrom's concept of polycentricity to study the dynamics between actors that are involved in and engaging with the participatory experiments. They conclude that these sandboxes are not sufficient to improve the potential of bottom-up, participatory innovation in a polycentric system. They think a better inter-actor alignment is required, providing more incentives, and expert and financial support for the bottom-up initiatives.

The issue of energy justice is covered by two papers. Kluskens, Vasseur and Benning (2019) aim to provide insight in what kinds of participation and distribution are perceived as most just and most likely to create local acceptance of wind parks, in particular in the Dutch province of Limburg [2]. Their analysis, using and operationalizing the concepts of procedural justice and distributive justice, demonstrate that different kinds of participation in different phases of the process are preferred; for instance, consultation or sharing of information. The same is true for different aspects of distribution of costs and benefits. The results indicate that the most preferred modes of participation do not necessarily cover all aspects of procedural justice. The authors also identified factors which influence perception of procedural and distributive justice. For instance, there are clear differences between the distribution of benefits between a privately developed wind park and a cooperatively developed wind park.

Hanke and Lowitzsch discuss the way vulnerable consumers may be better included in the energy transition, making use of new European legislation [6]. According to the authors, the empowerment of consumers to participate in renewable energy communities has great potential for a just energy transition; but, in practice, vulnerable consumers remain underrepresented in regional energy projects. The new European directive on energy obliges the European member states to facilitate the participation of vulnerable consumers and support their inclusion in the so-called "enabling framework" of the EU to promote and facilitate the development of renewable energy communities. However, the type and specific design of corresponding measures remains unclear so far. The authors stress the need to understand how vulnerability affects participation in renewable energy communities. They argue that both individual vulnerable consumers as well as energy communities need incentives and support to boost the capacity of these communities to include underrepresented groups.

As described in these articles, because of the rise of renewables and decentralized energy systems, and changing roles of traditional and new players, responsibilities and configurations will change as well. The rise and popularity of the term of prosumer, someone who consumes and produces energy, express the growing role of citizens. In addition, other new words such as prosumager show the changing role of citizens from passive energy consumers to more active participants in production, consumption and storage activities in the energy system.

5. Discussion and Conclusions

The aim of the conference as well as the Special Issue was to explore new pathways for community energy and storage. Several papers described new technologies and options for socio-technological configurations; for instance, the sea salt battery of DrTen as part of a local energy system, and Ecovat, a new type of thermal storage. Other papers discussed new methods of governance, new methods to take energy justice into account, and options for new legislation and technology–society interactions. Finally, some papers presented suggestions for new theoretical approaches and new types of modelling. Most striking, however, were the gaps that we found, between theory and practice, between modelling and real-world situations and between different theories and scientific approaches.

Regarding the theoretical aspects, transition theory, energy justice, energy governance, social movement theory, energy economy, commons and polycentric decision-making, approaches taking practices as starting point for analyses, and studies on user-inspired and responsible innovation, provide a strong basis in the analysis of community energy and storage. This enables further study on different ways in which various types of energy communities may contribute to the energy transition at various levels—the household level, the community level and "higher" levels—by co-governance, by co-design of technology, by introducing new values and by developing new types of ownership and economic participation.

Concerning empirical studies, we agree with several authors to continue conducting comparative studies, to see what kinds of community energy and community energy storage work in different national and regional contexts and why. The impact of "external" factors, such as different subsidy or tax schemes, may be studied further, as well as the relevance of "internal factors" relating to the manner of internal functioning, such as decision-making and inclusion of people with different gender, cultural and socio-economical backgrounds. Most important, however, is to study the way these initiatives succeed or fail to survive and the way they link internal and external strengths and opportunities. Studies on the experiences of various long existing energy communities with different types of ownership, private-community and public-community, and off grid systems in, for instance, Asia and North-America, may be inspiring for European cases. At the same time, studies on urban community owned sustainable smart grids in Europe may be useful for rural and non-rural areas in other continents.

In addition, we suggest to start modelling on community energy storage in close connection to real-world experiments, in different circumstances. As suggested by several authors, studies in which modelling of local energy systems is combined with case studies in neighborhoods, real pilots and the development of business models should continue and extend. Scenario building may be the next step, based on modelling, in-depth case studies and intensive interactive sessions with stakeholders, varying not only in terms of aims, storage technologies and governance options, but also in cost–benefit distributions. Because many storage technologies seem to be expensive and not always environmentally friendly, studies and experiments with various types of storage at different temporal and spatial scales are required, using not only proven techniques.

Pathways will differ from country to country, or even from region to region. Looking at the articles, we conclude that it is wise to study and develop community energy and storage transition pathways for each country separately. For the Netherlands, for instance, the development of integrated, citizen owned or governed energy systems started only recently. We suggest studies on different local systems, varying in type of community ownership and management, in grid connection and in storage system. Part of that should be further studied in terms of the functioning of new regulatory sandboxes to create more community-friendly legislation. In Germany, community energy and storage has been further developed. Here, studies may concern the willingness and ability of different types of house owners and tenants in different types of neighborhoods and using various type of storage, and the consequences of the changing legislation. For Denmark, which has developed even further when it comes to community energy, further study is required into new community ownership models, combining various energy technologies such as district heating, PV, wind energy and storage.

Most of the articles suggested the adaptation of national legislation to enable community energy and/or community storage. At least in the Netherlands, Denmark, Germany and Italy, the present support incentives are going to change, which makes community energy less profitable and attractive. Powerful private companies seem to be taking the lead, up to now, in successful community energy countries such as Germany and Denmark. If the new European legislation will enable citizen and community energy, and will stimulate experiments with regulatory sandboxes and new social business models, this will strongly stimulate community energy. However, is not only about policy and legislation: also energy companies, DSOs and others have to reflect on their roles. For many other European and non-European countries, one of the first research questions is how to mobilize citizens and to combine energy transition with social and justice issues, such as access to energy, citizens' empowerment and energy poverty.

In many countries, citizens are willing to participate in the energy system of the future. The growth of decentralized renewable energy, in general, has consequences for other, more traditional parties. The role of the state seems to be crucial, but has become less prominent, however, after the privatization and liberalization of energy markets in many countries. It is unclear what role traditional parties, DSOs, large energy and electricity companies may play in the new energy systems and if they are willing and able to find ways to include citizens in a proper way. Clearly, the relation between traditional and new energy actors is still in flux. The growing professionalization of community energy combined with adequate policy measures is important to secure a healthy balance and fruitful collaboration in the future.

Both community energy and community energy storage are new pathways in the energy landscape that will grow immensely in the coming decades. Furthermore, both will likely take on many different guises. We expect that the coming decade will be decisive regarding the questions of whether community energy, owned and governed collectively by citizens, will develop as a new and influential economic–social–technological configuration and whether other societal stakeholders begin a learning process which might result in a redistribution of roles and responsibilities. Yet, there are technological and social challenges of integrating energy storage in the largely centralized present energy system, which demands socio-technical innovation. Continuous and intensive attention is required to the societal dimensions of community energy and energy storage applications and the technological aspects of social innovation around community-based distributed generation and energy storage technologies. As variable renewables are also becoming big business for the traditional regime actors, this will add additional challenges for the local communities. It is more important to move political and moral topics of energy transition more to the core, both in science and society. Energy transition is not only about technological transitions, but also about transitions towards a new economy which is more fair, inclusive, democratic and sustainable as well as away from market domination and inequality. It means that future energy systems after transition should be ecological, inclusive and fair. In addition to emergence of active citizens, there are also new challenges such as populist opposition to climate change and energy transition. It is important to overcome these challenges by stimulating community energy and storage, in regulations and technology development, that fit the local scale.

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