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CHAPTER 10

Community Energy Storage: Governance and Business Models

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1. INTRODUCTION

As further described in accompanying chapters of this volume, the energy sector worldwide is facing increased innovation and disruption (Sioshansi, 2017). The ongoing changes in the energy sectors such as higher penetration of intermittent renewables, local energy initiatives, increasing electrification of transport and heating sector, and decreasing costs of energy storage for stationary and electric mobility applications as well as the need to balance of system is leading to an increased attention on energy storage systems (Barbour et al., 2018; Parra et al., 2017b; van der Stelt et al., 2018). Energy storage can enable effective energy system integration and get maximum benefits of local generation leading to flexible and resilient energy supply systems (Lund et al., 2015). In this way, energy storage can play an important role in achieving renewable energy and climate policy objectives such as higher penetration of renewables, decarbonization, energy security, and competitiveness as well as market and energy system integration (Koirala, 2017). Recent studies show that energy storage has a similar learning curve and cost reduction as the renewables such as solar photovoltaics (IRENA, 2017; Kittner et al., 2017). A central question is which policies and regulations will continue to keep energy storage in similar pathways as renewables.

The ongoing energy transition is driving the demand for energy storage. Energy storage can be implemented across the energy value chain as illustrated in Fig. 10.1. There are several ways and scales energy storage can be implemented in the energy systems such as residential energy storage, community energy storage (CES), distributed energy storage as well as large-scale energy storage (Next Kraftwerke, 2018; Parra et al., 2017b;

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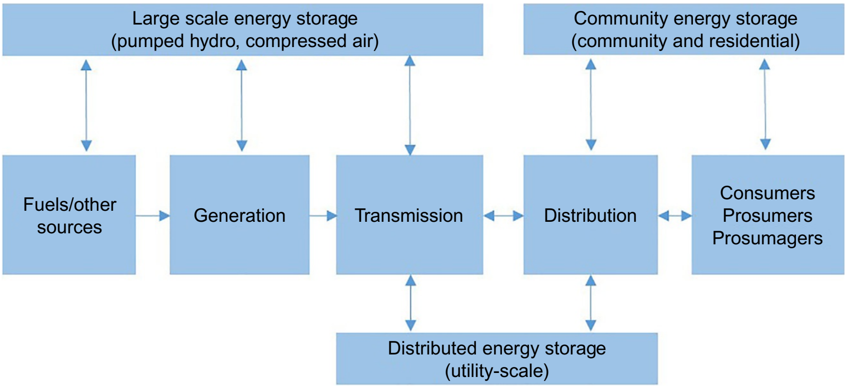

FIGURE 10.1 Positioning energy storage in energy system value chain.

SonnenCommunity, 2016). The need for CES is expected to grow in the future in line with the increasing local energy initiatives and distributed energy resources (DERs) penetration as well as to meet increasing demand for flexibility and self-sufficiency (DGRV, 2016; HierOpgewekt, 2017; IRENA, 2017).

Local communities are increasingly taking active roles in the energy system as evident from the increasing number of local energy initiatives (DGRV, 2016; HierOpgewekt, 2017; REN21, 2016; RESCOOP, 2016; van der Schoor et al., 2016; van der Schoor and Scholtens, 2015). Accordingly, the role of end-users in the energy system is changing from passive consumers to active prosumers and prosumagers, referring to their role in local energy production and storage, respectively (Schill et al., 2017; Sioshansi, 2017). In addition to individual behavioral change, collective action through community engagement is needed for wider energy system transformation (Koirala and Hakvoort, 2017; Koirala et al., 2018). These developments provide opportunities for further social and technical innovation toward smarter, decentralized, flexible, and inclusive energy system.

This chapter is focused on CES rather than the utility-scale energy storage. CES refers to a local energy storage unit or cluster of storage units with community ownership and governance, which can be grouped together to operate as a single unit to generate collective benefits such as higher penetration and self-consumption of renewables, reduced dependence on fossil fuels, reduced energy bills as well as revenue generation through multiple energy services. This definition excludes purely residential and utility-scale application. Actually, CES in terms of scope lies between these two applications. The key issues are aggregation of smaller storage units and energy sharing among the members. Intelligence through the digitalization facilitates clustering of residential energy storage as well as energy sharing among members and aims to make CES predictable and manageable. The community or microgrid organization of energy storage is increasingly making sense and becoming financially viable.

If more CES as well as community engagement therein is desired, not only the energy system as a whole but also the related business models, regulation, and governance should be transformed. Yet, pathways for such transition as well as changing roles and responsibilities of different actors therein are not yet clear. In this chapter, different options for such pathways are explored.

The chapter is organized as follows:

- Section 2 introduces CES and its prominent pathways;
- Section 3 discusses values streams and business models requirements for CES;
- Section 4 explains new types of regulation and governance required to make new business model for CES possible such as division of responsibilities and new revenue streams, followed by the chapter's conclusions.

2. COMMUNITY ENERGY STORAGE IN CHANGING ENERGY LANDSCAPE

In this section, first of all CES is conceptualized. Then, the main developments regarding energy transition, in particular community energy, will be explained. The problems, in particular concerning CES, are outlined.

2.1 Community Energy Storage: A Complex Sociotechnical System

The definition of CES varies among the scholars (Arghandeh et al., 2014; Barbour et al., 2018; Parra et al., 2015, 2016, 2017a; Roberts and Sandberg, 2011; van der Stelt et al., 2018). Roberts and Sandberg (2011) suggest CES as intermediate local energy storage solutions between residential and utility scale (Roberts and Sandberg, 2011). Residential energy storage are typically installed behind the meter in consumer premises and CES are shared by group of consumers. Several scholars have demonstrated the added benefits of CES over residential energy storage (Barbour et al., 2018; Marczinkowski and Østergaard, 2018; van der Stelt et al., 2018). This could be attributed to the size, economy of scale of CES as well as its potential applications in the energy systems. With the digitalization of the energy sector, residential energy storage can also be shared among the community members and used as CES (Lombardi and Schwabe, 2017; Next Kraftwerke, 2018; Rahbar et al., 2016; SonnenCommunity, 2016; Wang et al., 2018).

Parra et al. (2016) and van der Stelt et al. (2018) refer it as energy storage located at the consumption level with several potential applications and impacts to both end users and network operator (Parra et al., 2016; van der Stelt et al., 2018). According to these definitions, the interesting dynamics of CES is that the energy systems actors such as system operators as well as program responsible parties who are not the owner still might get the benefits. However, these definitions are limited to the location of energy storage and do not cover important issues such as virtual communities, community engagement, governance, ownership as well as business models. Alternatively, Barbour et al. (2018) define it as energy storage introduced for the community that can be shared between members who are typically but not exclusively located in the local community, opening up the possibilities for virtual CES (Barbour et al., 2018).

2.1.1 Technologies

CES consists of storage technologies, the energy storage management systems, energy converters as well as cloud services. Often they are embedded in the community energy system consisting of distributed energy resources and physical energy networks. Table 10.1 presents different technical components of the CES systems.

The energy storage technologies and balance of the systems such as charge controllers, inverters, and energy management systems as well as energy exchange platforms need to be compatible and interoperable with each other. This demands for standardization as several different technology developers are engaged in research and development of different energy storage system components. For example, Modular energy storage architecture (MESA) standards are being developed by consortium of electric

Table 10.1 Technical components of community energy storage

Components	Descriptions
Energy storage device	Residential energy storage technologies CES technologies
Balance of systems	Bidirectional inverters, charge controllers
Energy management systems	Energy storage management systems
Energy exchange platforms	Energy exchange platforms to enable peer-to-peer exchange, local balancing

utilities and technology suppliers worldwide to ensure interoperability, scalability, safety, quality, availability, and affordability of the energy storage components and systems (MESA, 2018).

As the technologies for CES such as energy storage technologies, bidirectional inverters, charge controllers, cloud services, and energy management systems are gaining maturity, it is important that simultaneously an enabling environment is created for business model innovation, community ownership, and participation as well as governance through flexibility in regulation as well as energy policy (Burger and Luke, 2017; Koirala and Hakvoort, 2017).

2.1.2 Actors

CES involves multiple actors, which includes households, local communities, energy co-operatives, housing corporations, local municipalities, national government, energy suppliers, intermediaries or aggregators, system operators, energy service and technology providers, regulators as well as local energy market operators. The intermediaries or aggregators are new actors with a role to organize a physical or virtual community, which can then be monitored, optimized, and managed.

These actors have different roles and responsibilities with variety of interests, expectations, and functionalities. For example, CES can be used for local balancing through the physical network of distribution system operators. At the same time, local congestion in an energy network can be managed through CES. The surplus energy can often be traded to the energy market through the aggregators. Yet, the actors are interdependent in the realization of their goals and different actors might have different expectations from the CES. For instance, households may want low-cost and local energy at their disposal while aggregators seek to maximize the value of their flexibility in the various energy markets. There are methods such as value-sensitive design and value case method to manage these conflicting interests and expectations (Berkers et al., 2015; Correljé et al., 2015).

2.2 Pathways for Community Energy Storage

Based on the current developments, two pathways for CES, namely, local and virtual, can be identified. A local CES is location specific, mainly within a distribution transformer. A virtual CES is often commercial with no location specificity and can expand to a national level and beyond.

2.2.1 Physical Local Community Energy Storage

In this case, there is a coherence between local community and a specific physical territory (Moroni et al., 2018; Walker et al., 2010). Local CES refers to shared residential as well as shared energy storage in a localized community. The members have shared goals such as energy independence, resiliency, autonomy as well as energy security and self-govern and own the CES. Shared local energy storage is emerging in the energy landscape.

Feldheim CES in Germany is a pioneering example for the local CES in which a 10-MWh energy storage not only provides local balancing services but also frequency regulation for a transmission system operators (NEFF, 2016). Often local CES are developed in co-operation and collaboration with different societal and energy system actors with the aim of maximizing self-consumption of local generation as well as identifying suitable conditions for sustainable operation of local energy storage (Enexis, 2012; Liander, 2017). For example, the pilots of CES in the Netherlands in Etten-leur, Rijsenhout, and Heeten are developed in collaboration with distribution system operators as well as energy storage and information technology developers (Enexis, 2012; Gridflex, 2018).

There is a huge potential for local CES in Island energy systems (Blechinger et al., 2014). Few examples of local CES being implemented in the islands are Pampus island near Amsterdam and Samso Island in Denmark (Pampus, 2018; SMILE, 2018).

2.2.2 Virtual Community Energy Storage

In this case, there is a no coherence between the community and a specific physical territory (Moroni et al., 2018). The community need not to be an actual neighborhood or physical community but a collection of participants or members who form a virtual community, typically through intermediaries. Due to liberalization and restructuring of the energy sector, there are enabling conditions for virtual CES. Accordingly, virtual CES networks are being developed worldwide (ARENA, 2018; IERC, 2018; LichtBlick Schwarmbatterie, 2018; Next Kraftwerke, 2018; SonnenCommunity, 2016).

For example, in Germany, there are already few commercial practices in virtual energy storage enabled by intermediaries such as SonnenCommunity®, Lichtblick – Schwarmbatterie® and Nextkraftwerke® (LichtBlick Schwarmbatterie, 2018; Next Kraftwerke, 2018; SonnenCommunity, 2016). Nextkraftwerke® digitally aggregates distributed energy resources as well as storage units and valorize the power and flexibility smartly in different energy markets and grid balancing services. Currently, Nextkraftwerke® has total networked capacity of 4200 MW and can even balance frequency fluctuations of the grid (Next Kraftwerke, 2018).

Similarly, the SonnenCommunity® is a growing network of above 10,000 end-users in Germany who produce, store, use, and share energy, Fig. 10.2 (SonnenCommunity, 2016). Distributed generation, energy storage technologies, and digital networking are the three basic building blocks of the SonnenCommunity®. In fact, SonnenCommunity functions as a

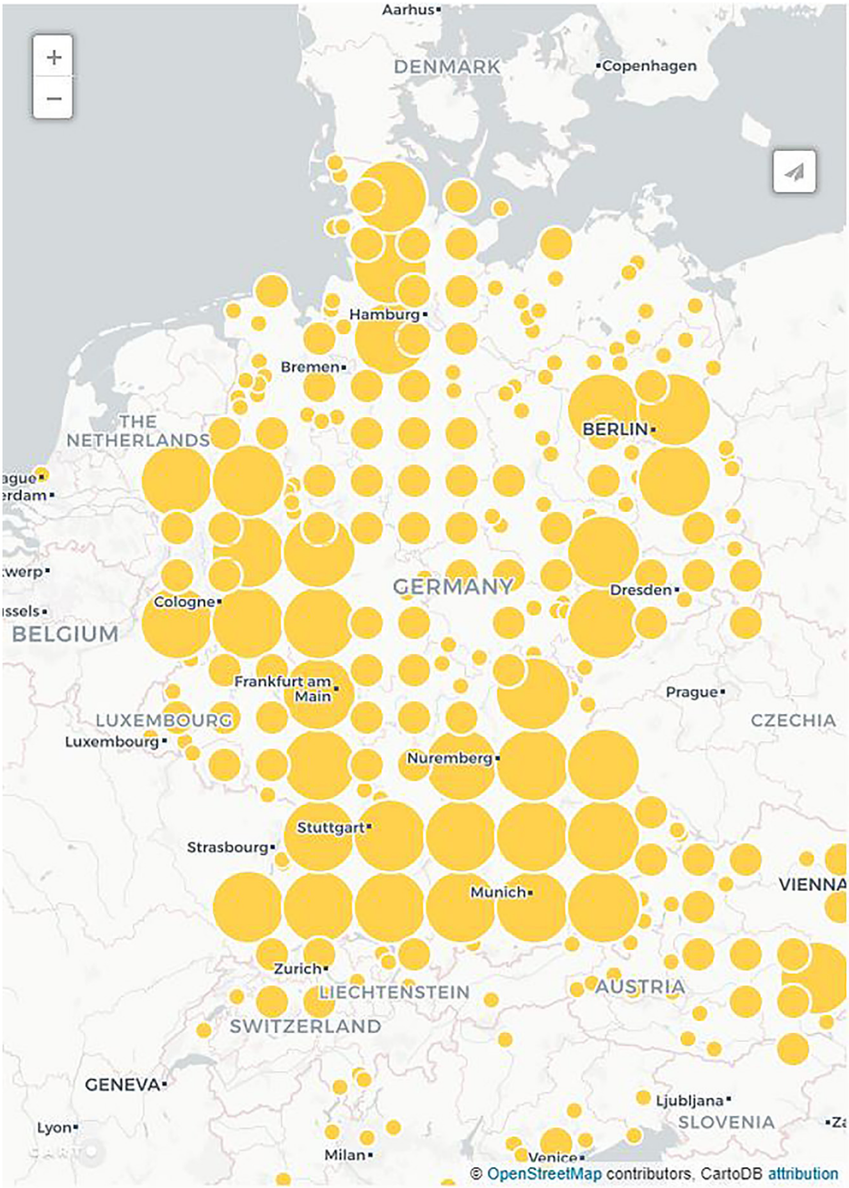

FIGURE 10.2 SonnenCommunity® in Europe. *(Source: Sonnen Gmbh.)*

shadow utility ensuring optimal energy balance within virtual network and minimizing the balance responsibility. Recently, the SonnenCommunity® is being realized beyond Germany to Austria, Italy, Switzerland, United Kingdom, The Netherlands, USA, and Australia. For example, An off-grid SonnenCommunity® is recently implemented in Puerto Rico and the Prescott valley in Arizona is building SonnenCommunity® with PV storage systems in 2900 new homes which will integrate 11.6 MW of solar and 23 MWh of energy storage (Spector, 2017).

The Schwarmbatterie® consist of interconnected batteries via the smart platform Schwarmdirigent®, enabling energy sharing between users (LichtBlick Schwarmbatterie, 2018). Similarly, the Storenet project in Ireland and the virtual power plant project in Adelaide are examples of virtual CES (ARENA, 2018; IERC, 2018).

The virtual CES can be used to provide energy services to other energy communities and system operators such as transmission and distribution system operators as well as balance responsible parties. Flexibility from CES can be aggregated and offered to a distribution system operator or the balance responsible party through a separate market for flexibility (USEF, 2016). Virtual CES can provide grid support functions such as voltage control, power factor correction, load leveling, and peak shaving as well as ancillary services.

Favorable regulatory conditions as well as sufficient grid capacity for exchange within virtual communities are prerequisite for this option. For example, SonnenCommunity® is emerging in EU due to enabling regulatory conditions, whereas in US, the European model could not be implemented as such due to different regulatory conditions. Moreover, this pathway does not necessarily defer the need for grid reinforcements entirely but do benefit from the liberalized energy markets and digitalization of the energy sector.

2.3 Local Energy Initiatives and Community Energy Storage

Existing and new local energy initiatives can offer a platform for the deployment of the CES systems (NEFF, 2016). As CES is still in its infancy, very few local energy initiatives are engaged with CES (DGRV, 2016; HierOpgewekt, 2017). Yet, the increasing number of local energy initiatives signifies huge potential for CES. For example, some of the local energy initiatives in the Netherlands are starting to engage with pilot projects in CES in collaboration with distribution system operators and technology developers (Enexis, 2012; Gridflex, 2018). In USA, Brooklyn microgird consisting of 400-kW Solar PV, 400-kW fuel cell, and 300-kW/1.2-MWh lithium ion batteries provides added benefits of economic incentives through demand charge reduction, grid relief, and grid services as well as energy security and resiliency (Brooklyn Microgrid, 2016).

CES may have an important role in creating a more efficient energy system (Koohi-Kamali et al., 2013; Lund et al., 2015). It can increase the self-consumption of local generation and decrease the energy import and network costs for local communities (van der Stelt et al., 2018). Other contributions of CES for the local communities are economic incentives, flexibility, reliability, resiliency, efficiency, sustainability, local circular economy, community engagement as well as sense of community (Koirala, 2017). Moreover, CES are important building blocks toward achieving community objectives such as energy autonomy, independence, and energy security. Table 10.2 provides examples of CES.

3. VALUE STREAMS AND BUSINESS MODELS FOR COMMUNITY ENERGY STORAGE

In this Section, an array of economic and noneconomic value streams for CES for different actors will be demonstrated and discussed. CES offers a range of technical, economic, environmental, and institutional values to its actors, as summarized in Fig. 10.3.

These values can be monetized differently by households, local communities, and the wider society. For example, these values are affected by community objectives such as costs reduction, emissions reduction, and resiliency as well as other geopolitical and socioeconomic factors (Koirala et al., 2018). Moreover, CES is expected to have interaction and co-ordination such as local balancing and strategic exchanges with member households, community as well as the larger energy system, leading to wider applications. Through the aggregation of individual households and shared energy storage, CES can have new roles of "flexibility provider" in the future energy system. The flexibility from CES can provide different technoeconomic value to the different actors in the energy system such as system operators, aggregators, and balance responsible parties. In addition, CES can curtail both demand and supply peaks and defer the need for the grid reinforcement.

However, it is a significant challenge to address different value expectations of different actors and combine these values into a meaningful business case (Berkers et al., 2015; D'Souza et al., 2015). Often, CES might

Table 10.2 Examples of community energy storage value streams

Examples	Technical specifications	Value streams (Technoeconomic)	References
Feldheim CES, Germany	10 MWh	Local balancing, network service (primary reserve)	NEFF (2016)
SENSIBLE project The meadows, Nottingham, UK	40 houses with residential energy storage and a CES	Peak shaving, higher self-consumption, hedging against price fluctuations	SENSIBLE (2018)
SMILE project, marina in Ballen, SAMSO Island	Linking renewables (solar and wind) to energy storage (thermal and electric)	Local balancing, higher renewables penetration, local circular economy	SMILE (2018)
Roding CES, Canada	500-kW/250-kWh Li-ion batteries	Higher renewable penetration, network services, peak shaving	eCAMION (2013)
Alkimos CES, Australia	250-kW/1.1-MWh lithium ion batteries	Network reinforcement deferrals, local balancing, higher renewables penetration	ARENA (2016)
SonnenCommunity®, virtual CES, Germany	Virtual community of 2–16 kWh energy storage and renewables in 10,000 households	Hedging against price fluctuations, peak shaving, reduced network costs, network services	SonnenCommunity (2018)

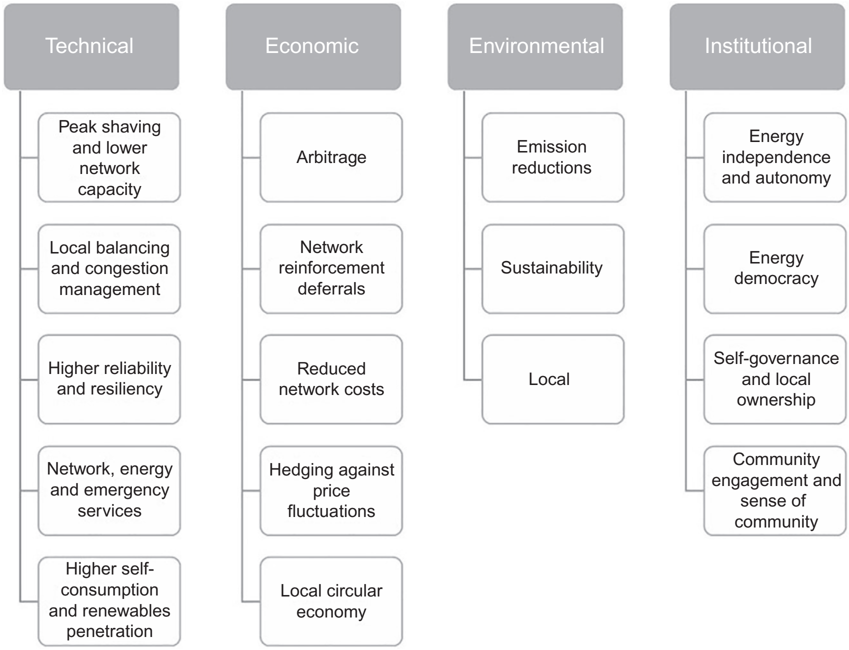

FIGURE 10.3 Value streams of community energy storage.

need to stack multiple of these value streams simultaneously to improve its economic feasibility, to minimize risk of single revenue streams, and to address multiple community objectives to improve its social acceptability (IEA, 2014; Stadler et al., 2016; Van Melven et al., 2018; Wolsink, 2012). The stacking of value is covered in Chapter 3 by Baak and Sioshansi in this volume. The environmental and institutional values are difficult to monetize but are often in line with the normative positions of local communities and might lead to wider societal benefits as well as acceptability. Table 10.2 provides an overview of different technoeconomic value streams captured by existing CES projects.

3.1 Business Model Developments

The business case for CES is not always straightforward and we have to deal with rapidly changing environments (D'Souza et al., 2015, 2018). Despite the falling costs, energy storage still requires very high upfront investment costs (IRENA, 2015). Several other factors such as availability of energy resources, existing energy mixes, conditions of physical infrastructures, market structures, regulatory framework, as well as demand and supply patterns affect the deployment of CES. At the same time, the traditional utility business models are being affected through changing ownership structures, increasing local generation as well as energy storage (Energy Post, 2013; EON, 2014; Morris and Pehnt, 2016). These developments have forced several energy utilities to develop new customer-centered business models for managing energy (Burger and Weinmann, 2013, 2016; Energy Post, 2013; EON, 2014). Accordingly, the incumbents such as EON and RWE in Germany are also changing their roles and strategies in the energy system and starting to focus on renewables, energy storage, distribution as well as customer solutions (Energy Post, 2013; EON, 2014). In this context, CES might have to compete with the utility-scale storage with economies of scale, highlighting the need for location-specific and robust business models.

If CES is desired to be scalable and successful, economic and noneconomic values need to be aligned through innovative business models. Moreover, business models for CES need to be dynamic with time, technology, and policy (Burger and Luke, 2017). Financial tunnel vision, existing regulation of energy storage and market design as well as involvement of multiple actors also challenges the business models development in CES (Berkers et al., 2015). At the same time, there are lot of uncertainties in CES emergence and its potential impact, in particular regarding technological adoption, energy services, and consumer preferences.

Business models are often seen as effective instruments to analyze, identify, and communicate the innovation potentials and it is all about how value is created, captured, and delivered (Osterwalder and Pigneur, 2010). Different perspectives and definitions of business models have been developed over the time (Casadesus-Masanell and Ricart, 2011; Dilger et al., 2017; D'Souza et al., 2015). However, existing business models concepts based on traditional profit-driven concepts of business economics are not appropriate for collective action-oriented systems such as CES (Dilger et al., 2017). People and actors are the missing links as they are being neglected in most concepts and definitions of traditional business models (Berkers et al., 2015; Dilger et al., 2017; Stähler, 2014). The sustainability of business models, however, depends on internal structure and capabilities of different actors (Stubbs and Cocklin, 2008). For the CES to be viable, the value must exceed the costs.

In this context, new business model developments methods to include people and social actors are emerging such as value case method and business model canvas (Berkers et al., 2015; Osterwalder and Pigneur, 2010). Value case method helps align economic and noneconomic values of multiactor

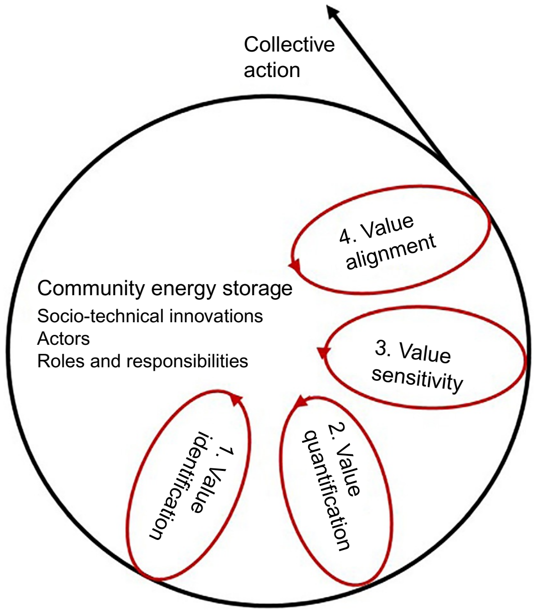

FIGURE 10.4 Operationalization of the value case method for community energy storage. *(Source: TNO, Adapted from Berkers et al., 2015.)*

and multivalue system and is being developed by TNO in the Netherlands (Berkers et al., 2015). It is implemented in four iterative steps, namely, value identification, value quantification, value sensitivity, and value alignment, Fig. 10.4 (Berkers et al., 2015). The ultimate outcome is a decision for collective action in which multiple values of different actors are adequately addressed. Business model canvas (BMC) is widely used in practice and academia due to its easy-to-follow visual representation and building blocks as illustrated in Fig. 10.4 (Osterwalder and Pigneur, 2010). BMC is used to develop business models in several research projects such as CITYOPT and IDEAS (CityOpt, 2018; IDEAS, 2018). Recently, the BMC concept has also been applied to the community energy systems by several scholars (Dilger et al., 2017; Herbes et al., 2017; Juntunen and Hyysalo, 2015; Koirala et al., 2016; Rodríguez-Molina et al., 2014). In the rest of this section, BMC is applied for local and virtual CES.

3.1.1 Business Model Canvas (BMC)

BMC might help to develop clear, concise, and focused business model for CES and to identify new value propositions that evolve with the changing energy landscape. Tables 10.3 and 10.4 illustrate the nine key elements of

Table 10.3 Business model canvas of the local community energy storage

Elements	Description	Example: Feldheim CES
Key partners	Local community member households, local communities, aggregators, energy suppliers, system operators, municipalities, regulators, technology and energy service providers	Wind turbine manufacturer (Enercon), Wind developer (Energiequelle), Transmission system operator (50 Hz), Feldheim regional regulating power station and Feldheim energy community
Key activities	Charging and discharging, storing, energy sharing, peak shaving, local balancing, congestion management as well as energy, network and emergency services, balancing and ancillary services, self-governance	Storing, load balancing, supplying, frequency regulation
Value propositions	Economic incentives, network reinforcement deferrals, local circular economy, higher self-consumption and renewables penetration, higher reliability and resiliency, autonomy, community engagement, self-governance and local ownership, sense of community, energy democracy	Grid stabilization, load balancing, network services, higher renewable penetration, local balancing, lower network capacity and grid reinforcement deferrals
Customer relations	Energy and network service providers, CES operators	Network service providers
Customer segments	Local community members, neighboring energy communities, system operators, aggregators, energy suppliers	Transmission system operator
Key resources	Energy storage technologies, physical grid, energy management system, energy exchange platforms	3360 li-ion batteries modules developed by LG chem (10 MW/10.79 MWh)
Channels	Energy exchange platforms, physical energy and communication networks	Energy network, energy community
Cost structures	Installation as well as operation and maintenance costs	Total investment cost of 13 million euros of which 5 million euros was subsidy of European regional development fund
Revenue structures	Avoided energy import costs, reduced network tariffs, revenue from flexibility provision as well as energy, network and emergency services, revenue from providing balancing and ancillary services	Primary balancing power to transmission system operator 50 Hz, avoided wind and solar curtailments

Table 10.4 Business model canvas representation of virtual community energy storage

Elements	Description	Example: SonnenCommunity
Key partners	Virtual community member households, energy storage and digital platform technology providers, energy service providers, system operators	Shareholders, installers, specialized dealers, energy storage associations, battery and technology suppliers
Key activities	Charging and discharging, storing, energy sharing, energy balancing in virtual community, valorize power and flexibility in different energy markets, balancing and ancillary services	Design, engineering, production, manufacturing, operation, marketing, installation, projects, sales and customer service
Value propositions	Economic incentives, clean and affordable energy, sustainability, energy independence, higher self-consumptions and renewables penetration	Reduction in energy costs, decentralized and clean energy
Customer relations	Digital platform providers,	Collaborative, cocreation, energy sharing, clean and affordable energy, analyze and control supply and demand of households, warranty of 10 years
Customer segments	virtual community members, System operators	Households and small businesses
Key resources	Energy storage technologies, energy management systems, digital platforms	Digital technologies, intelligent batteries, 10,000 existing members of SonnenCommunity, prizes and awards
Channels	Digital energy exchange platform enabled through energy grid, communication networks	Website, sonnenapp, SonnenCommunity, emails, telecommunications
Cost structures	Investment and operating costs for energy storage technologies, balance of the systems, energy exchange platforms	Research and development, raw materials, components, software, machinery costs, office space and human resources costs, logistics, taxes
Revenue structures	Avoided energy import costs, flexibility provision, avoided balance responsibility costs, revenue from providing balancing and ancillary services	Monthly fee from SonnenCommunity members, sales of sonnenbatterie, revenues from members, avoided program responsibility

business model canvas and its applicability in business model development of both local and virtual CES with the aid of specific case examples of Feldheim CES and SonnenCommunity®, respectively.

4. REGULATION AND GOVERNANCE OF COMMUNITY ENERGY STORAGE

In this section, the new forms of regulation and governance required to enable new business models maximizing the benefits and minimizing the costs for CES will be discussed. This involves changing roles and responsibilities as well as creating enabling conditions for the emergence of CES. The regulation and governance requirements may differ in local and virtual pathways. For example, the liberalized energy markets provide enabling conditions for virtual CES as evident by the emergence of virtual energy storage communities in Germany such as SonnenCommunity® and Nextkraftwerke® (Next Kraftwerke, 2018; SonnenCommunity, 2018). The regulators and policy makers also need to consider system and distributional effects of CES (Schill et al., 2017). In the rest of this section, we review current regulatory conditions and provide some recommendation for regulation and governance of CES.

4.1 New Regulations for Energy Storage

The current regulatory and governance arrangements were made for the traditional energy systems and do not provide the same level playing field for the CES, as they were not designed with collective action in the form of local energy initiatives, distributed energy resources (DERs) such as energy storage in mind. For example, the existing regulatory arrangements in most of the countries still treat energy storage as regular generation unit, which is the most important barrier for its deployment (Castagneto Gissey et al., 2018). On the other hand, in Germany it is still regulated as demand unit (GTAI, 2018). However, the technical characteristics of energy storage such as rate of charging and discharging, storage capacity, and energy losses as well as time decoupling of supply and demand are very distinct from those of generation and demand units. Moreover, current regulation does not fully recognize innovative products as well as services from CES such as ancillary and capacity-related services. In other words, there are regulatory barriers for realizing multiple energy services of energy storage. For example, a stable market or pricing signals does not exist for different energy services provided by the energy storage, hindering its investment.

With response to the changing energy landscape and increasing penetration of DERs such as energy storage, new regulations are being developed around the world, as summarized by four countries examples in Table 10.5. Some of these new regulation such as Spanish self-consumption regulation hinder implementation of CES, whereas other new regulations provide

Table 10.5 New regulations for energy storage

Country	Regulation	Implications
Italy	Decree no. 28/2011	TSO and DSOs to develop and manage distributed energy storage in order to increase the dispatch of intermittent generation. Recently, Italian energy agency has also published technical rules for the integration of energy storage (GSE, 2018).
Spain	Regulation on self-consumption, royal decree (900/2015) (MIET, 2015)	Ensure the same contribution from consumers with onsite generation to system costs as the consumers without DERs through "self-generated energy charge." The installation of energy storage is only possible with hourly energy generation and consumption meters so that the network and other regulated costs cannot be avoided. The regulation strictly forbids interconnection and energy exchange among group of consumers.
Germany	Renewables Act (EEG) 2017 (EEG, 2017)	According to EEG 2017, energy storage benefits from the connection privilege similar to renewables to the public grid. Energy storage also qualifies for the feed-in premium for the electricity fed to the public grid. EEG surcharge is only charged to the electricity fed to the public grid, provided that the metering requirements are fulfilled. However, energy storage is still regulated as consumers and subjects to different taxes and levies.
USA	FERC, RM 16-23 (FERC, 2018)	Recently, federal regulatory energy commission (FERC) of USA has enabled energy storage to participate in capacity, energy and ancillary service markets. The new rules adequately consider physical and operational characteristics of energy storage. The minimum size requirement is set to 100 kW.

enabling conditions for the emergence of CES such as in Germany and USA (EEG, 2017; FERC, 2018; MIET, 2015). For example, in Germany, every second rooftop solar PV is now combined with energy storage (GTAI, 2018). At the same time, countries like the Netherlands are lagging behind as local communities are not allowed to own and operate energy storage for the purpose other than pilot projects and experimental regulation (*experimentenregeling*).

4.2 Self-Governance and Ownership

CES has the advantage of collective organization and independent operation (Dilger et al., 2017). It shifts the energy governance from state and market to local energy initiatives in the form of self-regulation and self-governance. Yet, the CES governance has to coexist with state and market governance. Therefore, self-governance of CES depends on communities' abilities to be adaptive to co-ordinate with different governance circles (Cayford and Scholten, 2014). Self-governance of local and virtual CES might differ based on their social and technical complexity.

The ownership of CES is affected by financing requirements, operational requirements, social welfare issues as well as risk perceptions (Haney and Pollitt, 2013; Walker, 2008). The ownership of energy storage by system operators is unlikely due to the unbundling requirements (Energy Union, 2016). Accordingly, the ownership can be purely community based or shared with utility and public-private parties. Yet, the significant ownership and control need to be with local communities to qualify as CES (Table 10.6).

Table 10.6 Few examples of ownership and operation of community energy storage

Examples	Ownership	Operation
Feldheim CES (Local)	Third-party owned (joint venture by energiequelle, enercon, and local community)	Regional transmission system operator (50 Hz)
SonnenCommunity® energy storage (virtual)	Energy storage units owned by individual households and the software, which pools these storage units, is owned by SonnenCommunity®	Both home energy management system and SonnenCommunity in tandem

4.3 Flexibility, Energy Price Signals, and Future Role of Grid

With the increasing penetration of intermittent renewables, flexibility provision is becoming increasingly important as further explored in accompanying chapters in this volume. Currently, there are program responsible parties and metering responsible parties in the energy systems (ACM, 2018). In future, flexibility responsible parties also need to be defined and the flexibility provision needs to incorporate different actors of the energy system (USEF, 2016). Regulation needs to create enabling conditions to make flexibility potential of both local and virtual CES available to the energy system.

Market design needs to be inclusive of emerging technologies such as energy storage as they have potential to reduce the system costs. Both local and virtual CES need to receive appropriate price signals from different energy markets (Schill et al., 2017).

The role of electricity grid is also changing with the energy transition. Currently, the public grid extends till the metering point of each household. With decreasing costs of distributed energy resources and increasing willingness of local communities to take control of the energy systems, local communities in the future might be able to own a community microgrid. Local energy communities might even take over the ownership of part of the grid (Energy Union, 2016). In such case, the public grid will extend only until the distribution transformer and bidirectional power flows will be measured at the point of common coupling. In such a scenario, local CES will have important role in local balancing and avoiding peak network and energy tariffs. Behind the transformer microgrid concept is being tested in the Gridflex pilot project in the Netherlands (Gridflex, 2018).

Sometimes CES can be exchangeable to further reinforcement of the grid. In case of local congestion, CES might be used even when its costs are higher. Moreover, community energy systems need to be provided with right incentives to collaborate with system operators on energy management and grid issues.

4.4 Local Energy Market, Exchange Platforms, and Locational Net Metering

The energy exchange in both pathways of CES could take different form such as peer-to-peer exchange further enabled by innovative and transactive blockchain-based technologies (Brooklyn Microgrid, 2016; Gioitsas et al., 2015). There are already some platforms, which enable peer-to-peer energy trading, further described in Chapter 3 by Shipworth et al. For example, the Dutch platform Vandebron® allows Dutch consumers to buy their electricity directly from the independent renewable energy producers (Vandebron, 2017). Other examples for the peer-to-peer trading are OpenUtility® in the United Kingdom as described in Chapter 6 by Johnston, Stanley & Sioshansi and SonnenCommunity® in Germany. Using blockchain-based transactive solutions, a local market for energy is created in Brooklyn microgrid for transacting energy across existing energy infrastructures (Brooklyn Microgrid, 2016). These platforms create enabling conditions for the emergence of both pathways of CES.

Although *time-based energy balance or net-metering (saldering)* of the local generation has proven beneficial in increasing penetration of Solar PV in Dutch households, it has been counterproductive for the adoption of energy storage. In fact, net-metering is hindering the emergence of residential and CES in the Netherlands. *Location-based net metering* promotes co-operation among households through local energy exchange and might prove beneficial for the emergence of CES.

5. CONCLUSIONS

Community energy storage (CES) is emerging as another form of decentralized solution in the changing energy landscape to confront with technoeconomic, environmental, and societal challenges of the present energy systems. Based on current developments, the two dominant options for CES, namely, local and virtual can be identified. Several pilot and commercial projects are being developed to demonstrate the business case and viability of CES, as discussed in Section 2.3 of this chapter. These projects are crucial to show how CES works in practice, learn on new business and governance models as well to improve its public perception, acceptance, and boarder participation. CES is emerging as means to transform local communities from consumers to prosumagers and nonsumers.

CES brings along economic and noneconomic values and often multiple economic values needs to be stacked to have a viable business case. Some of the economic value streams are increased self-consumption of local generation, grid relief through peak shaving of both generation and demand, emergency services for critical infrastructures, short- and long-term decoupling of energy supply and demand, energy and network services as well as costs saving through grid reinforcement deferrals. The noneconomic value streams of CES such as sustainability, community engagement, energy democracy, sense of community, energy security as well as resiliency are in line with normative position of the local communities. CES has the potential to enhance the transformative role of the local communities, leading to the transition toward clean, sustainable, decarbonized, decentralized, and inclusive local energy system.

The business model canvas is a useful tool in documenting and visualizing key elements for both virtual and local options of CES. The virtual CES takes advantage of liberalized energy markets, whereas local CES exploit wider values through higher self-consumption, grid relief, local balancing as well as local congestion management. Current energy regulation seems to be more favorable for virtual pathways of CES as demonstrated by the emergence of intermediaries such as SonnenCommunity® in Germany. The existing regime needs to change to uptake these developments, consequently, the regulation, governance, and market structures.

The technical, operational as well as social characteristics of community energy storage needs to be adequately considered in new regulations. For local CES, the necessary preconditions are location-based net metering, community grid and local energy markets. Both local and virtual CES might benefit from the flexibility and responsibility provisioning, appropriate price signals as well as opportunities to participate in capacity, energy, and ancillary services markets. Enabling technical, regulatory, policy and market environment, innovative business models and governance structures, suitable conditions for collaboration between social and energy system actors combined with the intelligent energy management system will determine the emergence of CES bringing along the transformative impacts on the energy system.

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