USEF White Paper

Energy and Flexibility Services for Citizens Energy Communities

USEF

A solid foundation for smart energy futures

Authors & contributors

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A warm word of gratitude goes to representatives of REScoop, the European federation for renewable energy cooperatives, and members of the cVPP project, an Interreg NWE project focused on community-based Virtual Power Plants (cVPP), who have supported us with valuable comments, clarification of content and review of draft versions. While we have tried to capture and reflect all perspectives and views on energy and flexibility services for Citizens Energy Communities, the final product is a USEF publication and should be considered as expressing USEF's point-of-view only.

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1 Introduction

1.1 Background

Citizens Energy Communities are becoming increasingly popular at policy level and in society generally, for environmental, economic and social reasons. Each community may have one or more of a range of objectives and activities. For example, raising environmental and energy awareness from a social and/or economic perspective may result in an education program; or a desire to be self-supporting, or less reliant on energy suppliers, may lead a community to explore Distributed Energy Resources (DERs).

In line with the definition set by the European Commission (Clean energy for all Europeans package – Electricity Directive (recast) [1]), we refer to a Citizens Energy Community (CEC) as: a legal entity which is based on voluntary and open participation, effectively controlled by shareholders or members who are natural persons, local authorities, including municipalities, or small- and microenterprises.

A CEC's primary purpose is provision of environmental, economic or social community benefits, rather than financial profits, to its members. CECs may offer a range of services; some related to generation, distribution and supply, storage or aggregation of energy (typically from renewable sources); others are energy-related services e.g. to increase energy awareness and efficiency. It is important to note that members of CECs do not necessarily need to be living in the same geographical area e.g. members of a community that install and operate wind turbines can be distributed across a large area (or even across a country).

The need for an increase in controllable generation and load on the demand-side, *demand-side flexibility*, is becoming more urgent due to the rise of intermittent renewables and general shift towards electrification. USEF considers that flexibility can be deployed for multiple purposes and be used to serve a variety of customers and energy markets. For example, flexibility can be offered to the Distribution System Operator (DSO), Transmission System Operator (TSO) or Supplier[1] / Balance Responsible Party (BRP) who can then use it for constraint management, balancing or wholesale services.

As they increase in popularity, CECs are becoming more professional and are exploring opportunities to extend their roles, both in the energy system and in terms of the type of activities they can offer to their members. Flexible loads, controllable local generation and storage units can all offer flexibility value by allowing their load or generation profiles to be purposely changed from the planned generation or consumption pattern. As a result, activities related to demand-side flexibility could be considered complementary for communities e.g. by extending and increasing the economic value of a community (renewable) energy generation project by incorporating demand-side flexibility.

The USEF white paper, Flexibility Value Chain [2] , provides a comprehensive overview of demand-side flexibility services and the opportunities for different energy system stakeholders to unlock or receive value from them. The paper describes two distinct methods of unlocking value (i) *implicit demand-side flexibility,* reacting to variable supply and/or network costs, and (ii) *explicit demand-side flexibility,* flexibility offered directly to the DSO, TSO or BRP. The Flexibility Value Chains for both are illustrated in Figure 1-1. The focus of the USEF Flexibility Value Chain [2] paper was the valorization of flexibility services from end-users, Residential or Commercial & Industrial (C&I), who produce (and store) energy in addition to consuming it i.e. *Prosumers*. Where there are multiple Prosumers in a CEC, aggregating their loads can increase the opportunities to valorize flexibility and some of this is achievable by offering services directly to the community. This paper aims to extend the scope of the USEF Flexibility Value Chain by defining the type of energy and flexibility services that CECs can offer and the economic value they create. It can therefore act as a guideline for the harmonization and development of CECs and demand-side flexibility in the EU.

[1] Since every market participant requires a BRP, USEF considers that when flexibility is offered to the Supplier, it is (indirectly) offered to its BRP.

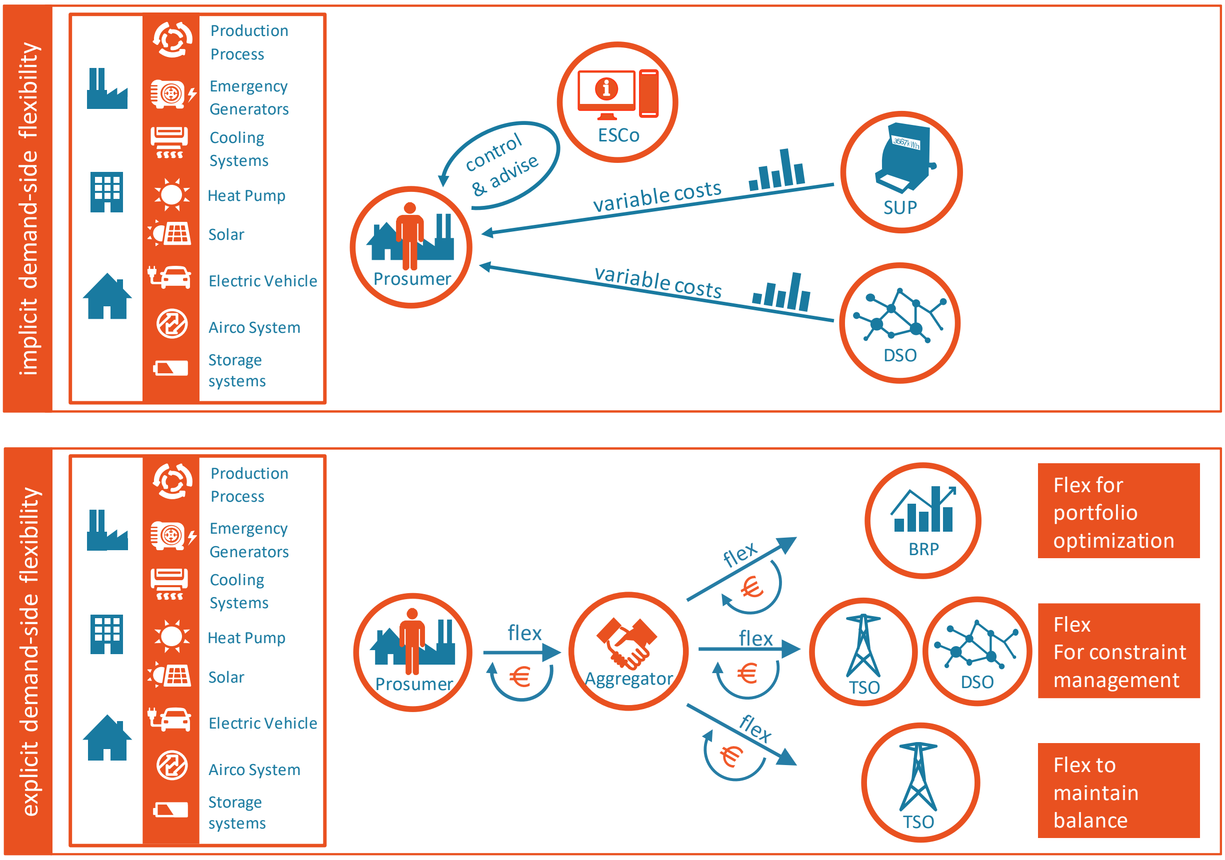

Figure 1-1: The USEF Flexibility Value Chain for implicit and explicit demand-side flexibility.

1.2 Reading guideline

To describe the economic value creation from the different services that CECs can offer, both to members and other energy system stakeholders, this paper is structured as follows:

- **Chapter 2:** describes the type of energy services that are commonly offered by CECs to their members. These are typically the initial driver for founding a CEC.
- **Chapter 3:** introduces the implicit and explicit demand-side flexibility services distinguished by the USEF Flexibility Value Chain for individual Prosumers. By definition these services are applicable to all Prosumers within the community, meaning that each member could valorize its flexibility through these services.
- **Chapter 4**: extends the scope of the flexibility services described in Chapter 3 by exploring the additional opportunities for a CEC to valorize flexibility based on an aggregated community load profile.
- **Chapter 5:** summarizes all the energy and flexibility services that can be offered by Prosumers within a community and reflects on the associated roles that can be assumed by a CEC.

Note the distinction between energy (Chapter 2) and flexibility (Chapter 3 and 4). Within USEF, there is always a clear distinction between energy and flexibility. Energy services are those which (potentially) affect the amount of energy consumed or produced by the Prosumer. Flexibility services specifically focus on deliberate (time limited) changes to the 'normal' energy profile.

This paper is designed to complement USEF The Framework Explained [3] and USEF Flexibility Value Chain [2]. The Framework Explained describes the key components of USEF and includes the USEF role model, market coordination mechanism and operating regimes. The USEF role model is a uniform description of flexibility market roles and the corresponding tasks and responsibilities. These can be implemented in various ways according to local market and business needs. To support stand-alone reading of this paper, the USEF role model can also be found in Appendix 1. Broader and more detailed information on the services that can be delivered using demand-side flexibility can found in the USEF Flexibility Value Chain paper.

2 Energy services for Citizens Energy Communities

Citizens Energy Communities (CECs) are typically founded for environmental, economic or social purposes and offer four types of energy services to members. These are illustrated in Figure 2-1 and explained in the subsections of this chapter.

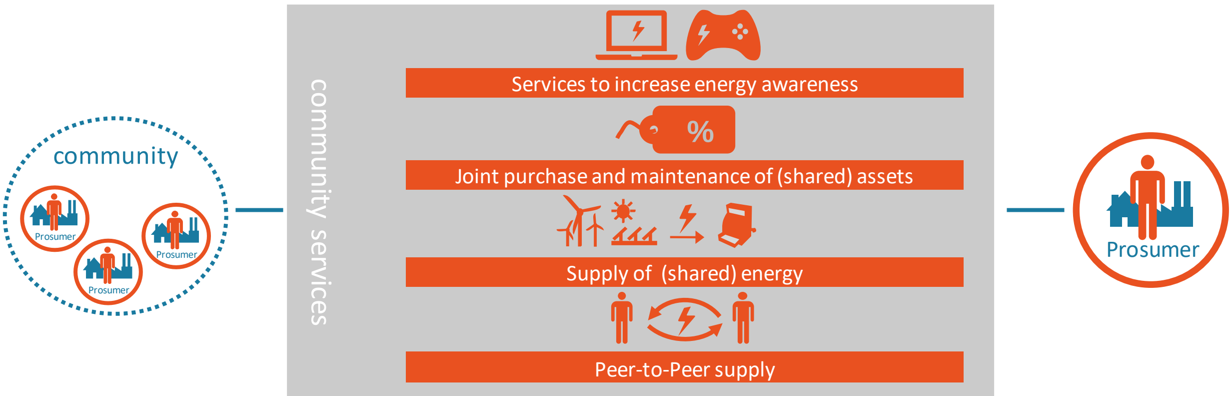

Figure 2-1: Four types of services that can be offered by a Citizens Energy Community (in the role of ESCo and/or Supplier) to the Prosumers within the community.

2.1 Services to increase energy awareness

Communities can focus on a variety of activities to provide environmental, economic or social benefits to their members e.g. creating a community garden, organizing social gatherings or pursuing a common goal to make the neighborhood more sustainable. Once such initiatives are established, social and information exchange between community members typically increases and can lead to initiation of new (complementary) activities[2]. The energy-related services that communities initially offer to their members are typically related to exploring the potential of DERs e.g. focusing on the joint purchase and maintenance of (shared) assets. It may be, though, that the first step is a simple focus on increasing energy awareness e.g. by providing energy diagnosis, energy consumption monitoring or by stimulating knowledge acquisition and exchange through dedicated workshops and training programs. Both improved energy awareness and social peer pressure help stimulate energy savings (thereby increasing energy efficiency). A community could, for example, offer energy benchmarking or challenges (gamification) services to its members through a platform that visualizes energy consumption (and benchmarks) and identifies energy saving measures. In the USEF role model it is typically the ESCo that offers such services to (individual) Prosumers. Hence, when a community offers such services to its members, it is interpreted as the community assuming the role of an ESCo.

2.2 Joint purchase and maintenance of (shared) assets

The majority of CECs are created by a desire to collectively generate (renewable) energy, resulting in the collective purchase of individual assets or common ownership of shared assets. For individual assets, the community could facilitate collective purchase of DERs e.g. rooftop PV panels, or collective purchase of insulation materials e.g. for walls and/or rooftops to increase (renewable) energy production and reduce energy consumption. Joint purchase of these assets can deliver multiple benefits for to community members. Initially, the process of information acquisition, procurement, installation and maintenance of assets becomes easier as members learn from each other, often making the process more appealing and less hassle. Additionally, joint

[2] Note that sometimes it is only a few members of the CEC that are initiating and organizing activities, sometimes referred to as the representatives or facilitators of the community.

purchase and maintenance can deliver financial benefits from the asset supplier because the community will hold a stronger negotiating position than an individual. The community could also offer to help financially e.g. by taking care of the initial investment and combining it with the offer of a refund scheme.

Communities focused on the realization of shared generation assets can offer DER opportunities to community members that would not normally have the technical or financial resources for an individual installation. These situations typically allow for consideration of a wider range of technologies (on a larger scale) e.g. a neighborhood wind turbine, with the community managing the financial settlement e.g. by offering debentures to its members. Note that joint purchase and maintenance of shared assets could also be offered by an existing centralized (profit-driven) market party (assuming the role of an ESCo).

2.3 Supply of (shared) energy

Once shared (renewable) generation is realized, the community automatically also takes on the role of Producer. Communities can sell their energy to centralized (profit-driven) Suppliers / BRPs, via a Power Purchase Agreement (PPA). However, a next step for the community could be to supply the energy to its own members. A growing number of CECs are taking on the role of Supplier[3]. In some cases, customers must be community members e.g. Ecopower; in others, this is not the case e.g. EWS-Schoenau. The Clean energy for all Europeans package[4] supports the concept of communities supplying collective generation to their members.

2.4 Peer-to-Peer (P2P) supply

The next opportunity for managing community generation and supply lies in (the administrative) exchange of energy between Prosumers within the community. There is increasing demand for this approach, commonly referred to as Peer-to-Peer (P2P) supply. P2P-supply clearly identifies the source of origin of the purchased energy[5] and can therefore make Prosumers less dependent on the large-scale fossil generation units owned by Suppliers. Theoretically, P2P-supply could make the role of the traditional Supplier, i.e. a centralized profit-driven market party, redundant in the long term. Cutting out the role of the traditional Supplier as middleman would likely reduce the costs for energy supply but would also require the community to take on the role of the Supplier. The community would then need to manage its expected surplus or deficit in energy production / consumption e.g. via a bilateral contract with a third market party (Supplier / BRP) or through wholesale market participation. The Clean energy for all Europeans package[6] also supports the concept of CECs accessing electricity markets to achieve this.

The community would also need balance responsibility. This could be delegated to a third party or the community itself could decide to do it (by taking on the role of BRP). As balance responsibility (from an economic perspective) is best managed using a much larger portfolio of Prosumers than a community typically has, it is often not practical[7] or financially feasible for a CEC to take on the BRP role. Nevertheless, there are an increasing number of initiatives that explore different ways to enable the community to adopt the roles of both Supplier and BRP in the future e.g. by using Blockchain technology. Some centralized (profit-driven) Suppliers currently offer P2P-services, with the Supplier handling the administrative exchange of energy between peers (not the actual physical exchange). Energy exchange can be based on different time periods, typically ranging from a yearly to a 15 minute match between the demand and supply of peers. Examples of Suppliers providing P2P-services in the Netherlands are Vandebron (yearly match of demand and supply between peers) and Powerpeers (15 minute match of demand and supply between peers).

There are also P2P-intiatives that manage the additional administration of local generation and consumption, e.g. to stimulate the physical (real-time) use of local generation within the community itself. This is commonly referred to as *shadow*

[3] Typically, CECs that take on the role of Supplier delegate balance responsibility to a centralized (profit-driven) BRP.

[4] The Clean energy for all Europeans package – Electricity Directive (recast) [1] states: "*Citizens energy communities should not face regulatory restrictions if they apply existing or future ICT technologies to share electricity from generation assets within the community between its members or shareholders based on market principles, for example by offsetting the energy component of members using the generation available within the community, even over the public network, provided that both metering points belong to the community.*"

[5] Note that the purchased energy typically does not equal the actual energy consumed, as this depends physical power flows.

[6] The Clean energy for all Europeans package – Electricity Directive (recast) [1] states: *"Member States shall ensure that citizens energy communities can access all electricity markets either directly or through aggregation in a non-discriminatory manner. "*

[7] Considering the administrative burden involved.

administration and is separate from the administration of the Supplier/Balance Responsible Party and so has no official role in the organization of the energy system. To stimulate the use of local generation, the shadow administration can be combined with the introduction of a (crypto) currency within the community. As Blockchain technology has characteristics that could fit with these developments (e.g. the distributed ledger), the technology is often used to facilitate (part of) the shadow administration. The (setup of the) administration is typically managed by the community itself (in the role of ESCo).

3 Flexibility services for Prosumers

To complement the energy services introduced in the previous chapter, community members could focus on increasing the economic value of DERs through the use of demand-side flexibility. This chapter introduces the different implicit and explicit demand-side flexibility services already distinguished by the USEF Flexibility Value Chain. By definition, all individual Prosumers within a Citizens Energy Community (CEC) could unlock the value of these services.

Demand-side flexibility can provide value to different parties - (i) *the Supplier/BRP:* for portfolio optimization, (ii) *the DSO:* for constraint management, and (iii) *the TSO:* for constraint management and to maintain the system balance. Flexibility is also of interest to the Prosumer, as the (economic) value of demand-side flexibility will (partly) flow back to the Prosumer, as an incentive to shift load and/or generation in time. Both implicit and explicit *demand-side flexibility* (DSF) can be used to unlock the value of flexibility. Explicit DSF can be used on demand (making it dispatchable) and can be tailored to the exact needs of customers or markets, making it of value for all types of products and markets. The scope of implicit DSF, where the Prosumer reacts to variable price signals, is typically limited to unlocking the value of flexibility for the Supplier/BRP and DSO, as the Prosumer is only exposed to (variable) tariffs from these two parties[8].

3.1 Implicit Demand-Side Flexibility

By exposing the Prosumer to variable energy supply and/or network costs that are time-dependent (€/kWh) or depend on the maximum load (€/kW), Prosumers can be incentivized to shift their controllable load and/or generation in time, thereby unlocking the value of DSF. Typically, local optimization of controllable assets is offered as a service to the Prosumer by an ESCo. Optimization services include: *self-balancing services*, *kW_{max} control (control of the maximum load)*, *Time-of-Use (ToU) optimization* and *emergency power supply.* Figure 3-1 lists these services. Note that the services are only financially viable if there is a (financial) incentive for each type of local optimization. The incentive types applicable to each service are discussed in more detail in the following paragraphs.

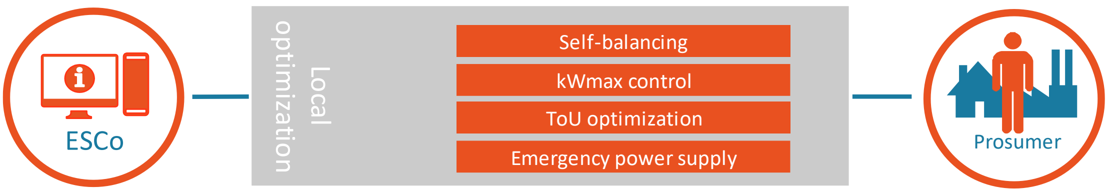

Figure 3-1: Local optimization services for Prosumers to unlock the value of implicit demand-side flexibility.

3.1.1 Self-balancing

Prosumers can be exposed to differences in variable costs (€/kWh), for *grid supplied electricity,* and variable remuneration for *feeding electricity into the grid*. This difference between the costs and the *feed-in tariff* can have different causes:

- Typically, the Prosumer's energy bill consists of **variable energy supply costs** charged by the Supplier. The variable energy supply costs for grid supplied electricity can be higher than the tariff offered to the consumer for feeding electricity back to the grid.
- Prosumers can also be exposed to **variable energy taxes,** typically taxes are only charged for grid supplied electricity, and not remunerated for feed-in electricity.
- If the Prosumer is also exposed to **variable network costs**, charged by the DSO, the network costs for grid supplied electricity are typically also higher than the offered feed-in tariff, which can be as low as zero. Note that variable

[8] In case of Prosumers connected to the distribution grid the capacity management costs of the TSO are typically passed on to the consumer as part of the network costs (charged by the DSO). And, the balancing costs of the TSO are typically passed on to the consumer as part of the energy supply costs (charged by the Supplier).

network costs are mostly applicable for Commercial & Industrial (C&I) Prosumers, whereas Residential Prosumers can only be exposed to fixed costs (kWh independent) e.g. only dependent on the installed meter capacity.

The difference in grid-supplied electricity costs and the feed-in tariff may make it financially viable to use flexibility to increase self-consumption of in-home (renewable) electricity generation. However, where national regulations allow for *net-metering*, i.e. administrative balancing of net load and net generation, self-balancing is not necessarily financially viable. This depends on the time period in which net-metering is calculated e.g. when net-metering is applied to a calendar year (e.g. currently the case in the Netherlands), self-balancing does not make sense. When net-metering is only allowed for a shorter time period e.g. hourly (currently the case in Denmark), financial value can be created by self-balancing. The difference between situations with and without net-metering is illustrated in Figure 3-2, based on variable energy supply costs and variable energy taxes, as these are typical for Residential Prosumers.

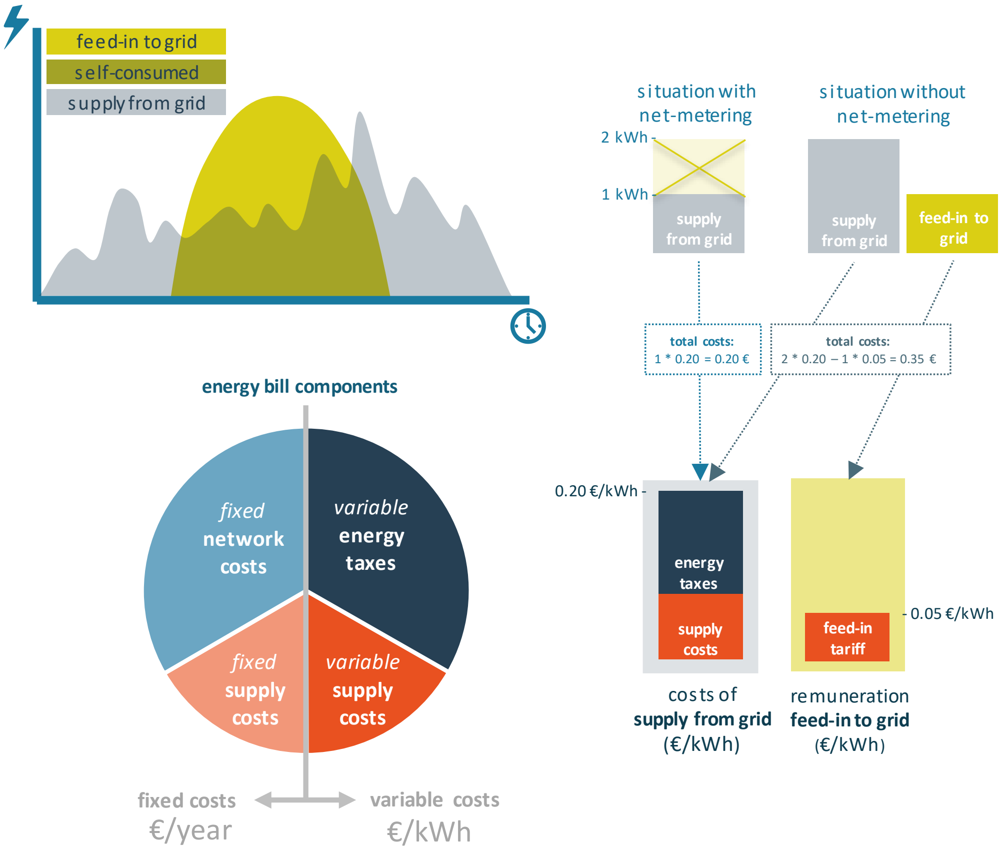

Figure 3-2: Example of the cost-breakdown of an energy bill of Residential Prosumers. Illustrating the link between the costs of supply from the grid and remuneration for feed-in to the grid. The feed-in tariff is lower than the costs for grid supplied electricity, due to lower supply costs and the absence of energy taxes in the feed-in tariff. Hence, net-metering is financially attractive in this situation. Note that the distribution of the different energy bill components is based on a theoretical example, typical for Residential Prosumers.

3.1.2 KW$_{max}$ control

As well as variable network costs, the DSO can also expose the Prosumer to a cost component based on the Prosumer's maximum load (kW$_{max}$), during certain time periods and/or the connection capacity limit[9]. This is typically the case for C&I Prosumers. Deploying demand-side flexibility can reduce the maximum load and, therefore, the Prosumer's energy bill.

3.1.3 ToU Optimization

The variable price of grid supplied electricity and the feed-in tariff can also be time dependent. Variable price tariffs are referred to as Time-of-Use (ToU). Prosumers can reduce their energy bills by deploying demand-side flexibility i.e. allowing load to be from high-price intervals to low-price intervals (or vice versa in case of generation shifting). Note that both network costs and

[9] Note that the maximum load can be positive and/or negative, respectively based on the peak in consumption and/or production.

energy supply costs can vary in time and are not necessarily aligned, as these reflect the needs of the DSO and Supplier respectively. Energy taxes are not typically time varying, as they do not relate to energy system costs at the time of consumption.

3.1.4 Emergency power supply

An ESCo can also offer Prosumers an emergency power supply service during grid outages. The economic value of emergency power supply can be expressed as the Value of Lost Load (VoLL) i.e. the estimated amount the Prosumer is willing to pay to avoid disruption in electricity supply. The VoLL typically depends on the potential damage from grid outage which, in turn, depends on the type of Prosumer (e.g. Residential or C&I). Enabling the use of demand-side flexibility for islanding for emergency power supply may require additional investment e.g. for storage and synchronization systems.

3.2 Explicit Demand-Side Flexibility

Prosumers receive (economic) rewards for explicit demand-side flexibility i.e. for agreeing to respond to BRP, DSO or TSO requests to adjust their load or generation profile. To facilitate DSF, USEF's role model assigns an Aggregator[10] in a central position in the Flexibility Value Chain, as a retailer of flexibility between the Prosumer and the Flex Requesting Parties (FRP) i.e. the BRP, DSO and TSO.

The Aggregator is responsible for acquiring flexibility from Prosumers, aggregating it into a portfolio, creating services that draw on the accumulated flexibility and offering these to different markets, serving different market players. The reward value that the Aggregator receives in return is shared with Prosumers as an incentive to control their load or generation[11]. The type of flexibility services that an Aggregator can valorize are classified into *wholesale services, constraint management services, balancing services* and *adequacy services*. All types are listed in Figure 3-3. More information on these services can be found in the USEF Flexibility Value Chain paper [2].

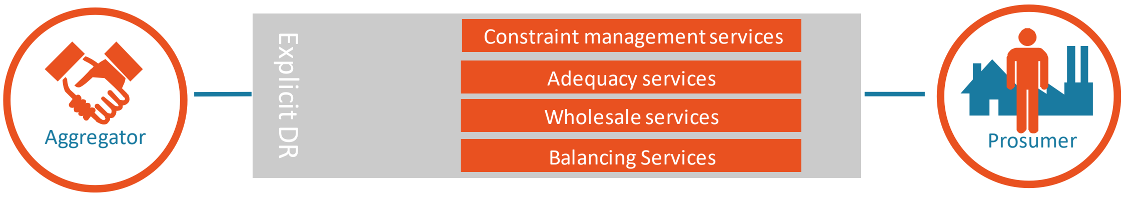

Figure 3-3: Type of explicit demand-side flexibility services that can be valorized by an Aggregator through the use of the Prosumer's flexibility.

[10] The Aggregator is a market role that can be taken by either existing market parties (Suppliers) or new entrants.
[11] Aggregators can also provide non-financial value in return to the Prosumer, e.g. by providing insight into consumption patterns or providing home energy management tools that help the Prosumer to become more energy efficient.

4 Flexibility services for Citizens Energy Communities

Membership of a Citizens Energy Community (CEC) can offer increased opportunities to valorize flexibility, through optimization of the aggregated community load profile. To this end, the community could focus on (complementary) activities that are based on optimizing the flexible (shared) DERs. This chapter classifies these additional services and discusses their potential economic value creation.

4.1 Demand-side flexibility based on the aggregated community profile

To assess which additional flexibility optimization services can be offered to CEC members, different implicit and explicit demand-side flexibility services (as defined in Chapter 3) are considered (below) from a community perspective.

4.1.1 Community self-balancing

Some countries allow for net-metering of shared assets within a (local) CEC e.g. in Greece there is a virtual net metering provision[12] and, in the Netherlands, regulation allows for net-metering of shared assets within the ZIP-code area. Again it is critical to consider the time period for net-metering. Where net-metering is applied to a calendar year, community self-balancing is not meaningful from an economic perspective. However, when community net-metering is limited to shorter time periods, use of flexibility to increase community self-consumption could create economic value but this depends on the price difference between grid supplied electricity and the feed-in tariff (as explained in Section 3.1.1).

Additionally, where the CEC is operated as a micro-grid or 'closed distribution grid' e.g. in a multi-tenant building, or an urban district, fed by the same substation and considered as a single connection by the Supplier/BRP and DSO, it could also be financially viable to increase community self-consumption. In most countries, it is not (yet) legal for communities to operate the local grid as a micro-grid, as legislation dictates that Prosumers are connected to a grid that is operated by the designated DSO (or TSO). However, some countries are experimenting with new rules e.g. in the Netherlands there are currently a couple of projects that have been awarded exemption from these rules. The Clean energy for all Europeans package[13] supports the concept of CECs being allowed to make agreements with, or perform the activities of, a DSO which would make it possible for them to control their own local grid. It also raises the possibility of DSOs considering a community as a virtual single connection to the grid, to allocate network charges proportionally, based on the actual use and costs of the system[14].

4.1.2 KW_{max} control of the community load

Optimization, to reduce the maximum load of the aggregated community profile, is currently only financially viable if the community is operated as a micro-grid and considered as a single connection by the DSO. If the community is responsible for the operation of its micro-grid (and hence takes on the role of the DSO), it could use KW_{max} control for all types of constraint management services e.g. to avoid or delay local grid investment costs. The community could also be exposed by the DSO to a kW_{max} cost component based on the connection between its micro-grid and the main grid. To simulate kW_{max} control of

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[12] This regulation allows farmers and specific legal entities that undertake work of public value to install PV panels far from the point(s) of electricity consumption.

[13] The Clean energy for all Europeans package – Electricity Directive (recast) [1] states: "*The Directive foresees a possibility for Member States to allow a citizens energy community to become a distribution system operator either under the general regime or in accordance with Article 38 as the so-called "Closed Distribution System Operator*". And, "*Citizens energy communities may conclude an agreement with a relevant distribution system operator or transmission system operator to which their network is connected on the operation of the citizens energy community's network.*"

[14] The Clean energy for all Europeans package – Electricity Directive (recast) [1] states: "*Citizens energy communities are subject to non-discriminatory fair, proportionate and transparent procedure and charges, including registration and licensing, and transparent and non-discriminatory and cost reflective network charges in line with Article 16 of the [Electricity Regulation] ensuring they contribute in an adequate and balanced way to the overall cost sharing of the system.*"

communities in the future, the DSO may possibly consider the community as a virtual single connection to the grid, allowing it to stimulate community use of demand-side flexibility in order to reduce the aggregated community load.

4.1.3 ToU Optimization

CECs might benefit from a community tailored tariff offer from the centralized (profit-driven) Supplier. Communities have a better negotiating position than individual Prosumers and this could be exploited by asking the Supplier to offer a tariff scheme that suits the local situation (taking into account the aggregated community profile). In this situation, each Prosumer could choose[15] to become a customer of the Supplier and profit from the community tailored offer. ToU optimization would only be financially interesting if the tariff varies over time. However, in this case optimization would typically still be applied on individual Prosumer level, as the Prosumer's energy bill would be based on their own consumption profile.

4.1.4 Emergency power supply

Where assets are shared e.g. shared storage units, emergency power supply optimization would typically be based on limiting the community's aggregated Value of Lost Load (VoLL) during grid outage. The VoLL depends on the type of Prosumers within the community and the potential damage from grid outage. For example, a community (in the role of ESCo) could decide to install a battery as a back-up in grid outage situations, in order to reduce the community's VoLL.

4.1.5 Explicit DSF services

When it comes to valorizing flexibility through aggregation, CECs could collectively reach out to Aggregators and negotiate the participation of the whole pool. However, it could also be the community itself that takes on the role of Aggregator (instead of an already existing (profit-driven) market party), by assuming the role of the flexibility retailer, between its members and Flex Requesting Parties (FRPs) i.e. the BRP, DSO and TSO.

[15] Note that each Prosumer is entitled to its freedom of choice for Supplier/BRP.

5 Summary of energy and flexibility services for Citizens Energy Communities

To realize environmental, economic or social benefits for its members, CECs can offer them a range of services. To complement energy services, and increase the economic value of (shared) DERs, communities could consider services related to demand-side flexibility. Individual Prosumers can optimize flexibility to offer implicit and explicit demand-side flexibility services. Additionally, Prosumers that are part of a community could, in some situations, profit from additional (implicit) flexibility services, based on valorizing flexibility within the community itself. This chapter summarizes all the energy and flexibility services described in this paper and reflects on the associated roles that a CEC can take.

Figure 5-1 illustrates all the energy and flexibility services distinguished in this paper. In Chapter 2, four different types of energy services were discussed: ① Services that increase energy awareness, ② Services to facilitate the joint purchase and maintenance of (shared) assets, ③ Supply of (shared) energy, and ④ Peer-to-Peer supply, allowing Prosumers within the community to (administratively) exchange energy with each other. Typically, ② and to a lesser extend ① are the reason to establish a CEC in the first place, in which case the community (in the role of ESCo) offers these services to its members. Once collective generation is realized, a next step for the community could be to assume the role of Supplier, thereby enabling the supply of (shared) energy to its members and cutting out the role of the traditional centralized (profit-driven) Supplier as the middle-man. This is illustrated in Figure 5-2. Theoretically, P2P-supply could also be facilitated by the community, which would also require the community to take on the role of Supplier. As discussed in Chapter 2, at present, P2P-services are typically offered by (profit-driven) market parties in the role of Supplier / BRP.

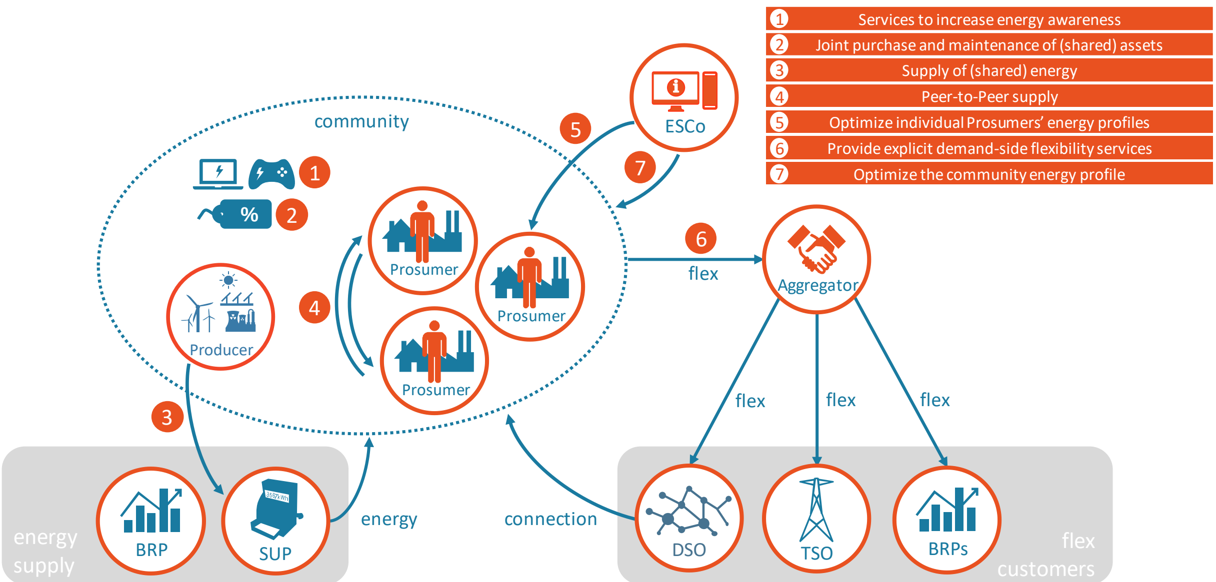


Figure 5-1: Illustration of all energy and flexibility services that can be offered to the Prosumers within a Citizen Energy Community.

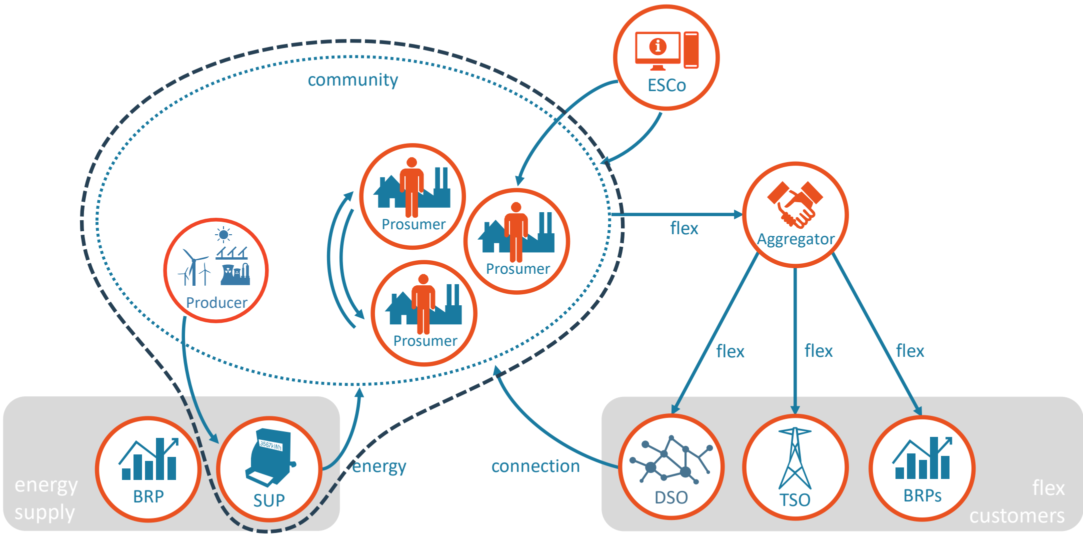


Figure 5-2: Illustration of the Citizens Energy Community that takes on the role of both Producer and Supplier, thereby having the possibility to supply shared generated energy to its members.

By definition, the implicit and explicit demand-side flexibility services distinguished by the USEF Flexibility Value Chain (described in Chapter 3) are also applicable for all individual Prosumers within an Energy Community. Optimization for implicit demand-side flexibility services can be offered by an ESCo, while optimization for explicit demand-side flexibility services can be offered by the Aggregator (numbers ⑤ and ⑥ in Figure 5-1). It is important to note that the CEC can also take on the role of an ESCo and/or Aggregator. This is illustrated in Figure 5-3, where the community itself (in the role of ESCo and/or Aggregator) offers flexibility optimization services to unlock the economic value of implicit and explicit demand-side flexibility services for its members.

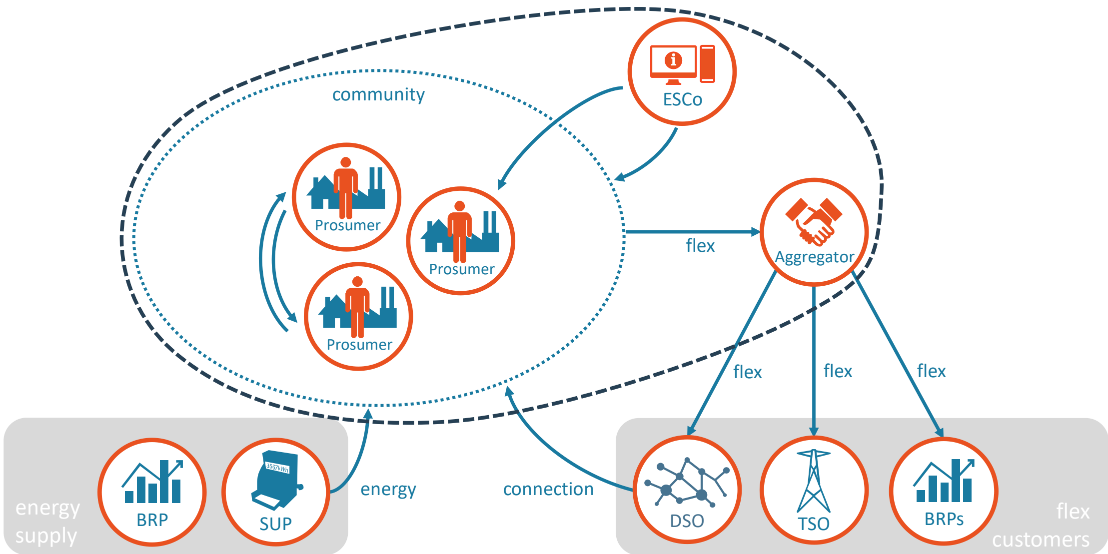


Figure 5-3: Illustration of the Energy Community that takes on the role of both ESCo and Aggregator, thereby having the possibility to offer optimization for both implicit and explicit DSF services to its members.

A community assuming the role of ESCo could increase opportunities to valorize implicit demand-side flexibility. This would rely on optimization of the aggregated community load profile (number ⑦ in Figure 5-1), as discussed in Chapter 4. Depending on regulation (with respect to net-metering) and tariff structures, it could be financially viable to increase community self-balancing and/or apply KW_{max} control. However, both self-balancing and KW_{max} control are only financially viable if the community is operated as a micro-grid which is considered as a single connection by the DSO[16]. Where this is the case, the community is responsible for the operation of its own micro-grid and takes on the role of the DSO, as illustrated in Figure 5-4. If the community is responsible for the operation of its micro-grid, it could use self-balancing and KW_{max} control to reduce energy and grid costs (related to grid investments and losses of the local grid). However, it is not yet possible for most communities to exploit these options as most European countries require Prosumers to be connected to a grid that is operated by the designated DSO (or TSO). It is expected that these regulations may change in the near future (supported by the Clean energy for all Europeans package [1]), thereby enabling CECs to assume DSO activities.

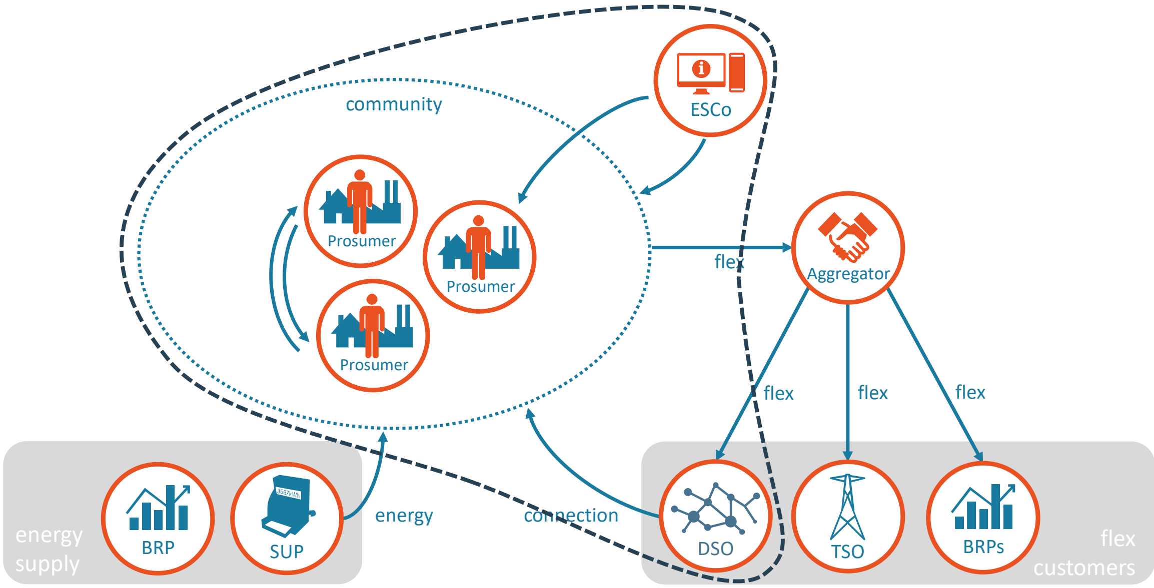


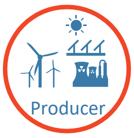
Figure 5-4: Illustration of the Energy Community that takes on the role of both ESCo and DSO, thereby offering demand-side flexibility services based on optimizing the aggregated community load profile, e.g. to increase self-balancing or to apply kWmax control.

In conclusion, this paper provides a categorization of the type of (complementary) services that communities can offer to their members, and the economic value creation of those services, with a specific focus on valorization of demand-side flexibility. This can help the harmonization and development of CECs by supporting their role within the energy system and, in turn, help CECs to unlock the value of Prosumer flexibility, which is considered essential to facilitate energy transition. USEF invites all major stakeholders to participate in its work, to help create a common basis and understanding, to accelerate the development of, and effective use of, demand-side flexibility.

[16] Self-balancing could also be stimulated through regulation in situations without the community being operated as a micro-grid. This could e.g. be done through a regulation that allows net-metering (limited to short periods of time) for shared assets.

Appendix 1 The USEF role model

This appendix describes the different roles distinguished in the USEF roles model. Note that, in practice, roles can be combined by a single market party e.g. the DSO can also take the role of MDC, and the TSO can also take the role of ARP.

	A Prosumer can be regarded as an end-user that no longer only consumes energy, but also produces energy. USEF does not distinguish between residential end-users, small and medium-sized enterprises, or industrial users; they are all referred to as Prosumers. In this text we also use the term Prosumer for end-users that have controllable assets (Active Demand & Supply) and are thereby capable of offering flexibility.
	In USEF, Active Demand & Supply (ADS) represents all types of systems that either demand or supply energy which can be actively controlled. This enables the ADS device to respond to price and other signals from the Aggregator and to provide flexibility to the energy markets via the Aggregator. The Prosumer owns the device and defers responsibility for controlling its flexibility to the Aggregator. The Prosumer has final control over its assets, which means the Aggregator's control space is limited by the Prosumer's comfort settings. Hence the Prosumer is always in control of its comfort level; if the associated remuneration is high enough however, the Prosumer might be willing to compromise on its comfort levels. In this context we also use the terms units, assets or resources when referring to ADS.
	The role of the Aggregator is to accumulate flexibility from Prosumers and their Active Demand & Supply and sell it to the BRP or Supplier, the DSO, or (through the BSP) to the TSO. The Aggregator's goal is to maximize the value of that flexibility by providing it to the service defined in the USEF Flexibility Value Chain that has the most urgent need (or value) for it. The Aggregator must cancel out the uncertainties of non-delivery from a single Prosumer so that the flexibility provided to the market can be guaranteed. This prevents Prosumers from being exposed to the risks involved in participating in the flexibility markets. The Aggregator is also responsible for the invoicing process associated with the delivery of flexibility. The Aggregator and its Prosumers agree on commercial terms and conditions for the procurement and control of flexibility.
	The role of the Supplier is to supply energy, to buy the energy, hedge its position across all timeframes, manage the energy and the associated risks, and invoice energy to its customers. The Supplier and its customers agree on commercial terms for the supply and procurement of energy. A Supplier is a specialization of the Trader role as it exchanges energy with Prosumers as well.
	The role of the Producer is to feed energy into the energy grid. In doing so, the Producer plays an important role in the security of the energy supply. The Producer's primary objective is to operate its assets at maximum efficiency. Though its responsibility remains unchanged, the introduction of demand-side flexibility and changes to the merit order can alter its operating conditions quite drastically, since renewable energy sources such as wind and solar power have a relatively low operating expense and compete with existing power generation units.
	A Balance Responsible Party (BRP) is responsible for actively balancing supply and demand for its portfolio of Producers, Suppliers, traders, Aggregators, and Prosumers, with the means granted by those actors. In principle, everyone connected to the grid is responsible for his individual balance position and hence must ensure that at each imbalance settlement period (ISP), the exact amount of energy consumed is somehow sourced in the system, or vice versa in case of energy production. The Prosumer's balance responsibility is generally transferred to the BRP and this is usually contracted by the Supplier. Hence, the BRP holds the imbalance risk for each connection in its portfolio of Prosumers.
	The DSO is responsible for the active management of the distribution grid and introduces the system operation services defined in the USEF Flexibility Value Chain. The DSO is responsible for the cost-effective distribution of energy while maintaining grid stability in each region. To this end the DSO will 1) check whether demand-side flexibility activation within its network can be safely executed without grid congestion and 2) may purchase flexibility from the Aggregators to execute its system operations tasks.

TSO	The role of the Transmission System Operator (TSO) is to transport energy in each region from centralized Producers to dispersed industrial Prosumers and Distribution System Operators over its high-voltage grid. The TSO safeguards the system's long-term ability to meet electricity transmission demands. The TSO is responsible for keeping the system in balance by deploying regulating capacity, reserve capacity, and incidental emergency capacity.
FRP	Flex Requesting Party (FRP), a (market) party interested in using flexibility for a specific service. USEF distinguishes the TSO, DSO and BRP as FRPs.
CRO	The Common Reference Operator (CRO) is responsible for operating the Common Reference, which contains information about connections and Congestion Points in the network.
MDC	The Meter Data Company (MDC) is responsible for acquiring and validating meter data. The MDC plays a role in USEF's flexibility settlement process and the wholesale settlement process. In many countries, this role is performed by the DSO.
ARP	The Allocation Responsible Party (ARP) is responsible, within a metering grid area, for establishing and communicating the realized consumption and production volumes per ISP, either on the consumer level or on the aggregated level. The realized volumes are primarily based on actual measurements but can also be based on estimates. The allocation volumes are input for the flexibility settlement process and the wholesale settlement process.
BSP	A Balancing Service Provider (BSP) is a market participant providing Balancing Services to the TSO. Each Balancing Energy bid from a Balancing Service Provider is assigned to one or more Balance Responsible Parties. In the USEF framework we have considered a BSP as a specific type of BRP and, therefore, did not make this role explicit. Note that the BSP role is not distinguished in all EU member states.
Trader	A Trader buys energy from market parties and re-sells to other market parties on the wholesale market, either directly on a bilateral basis (over the counter) or via the energy exchange (day-ahead, intraday) etc.
Exchange	An Exchange provides brokering between Traders, Suppliers, BRPs and Aggregators.
ESCo	The ESCo (Energy Service Company) offers all kind of energy-related services to Prosumers. These services include insight services, energy optimization services, and services that facilitate the joint purchase and maintenance of (shared) assets. If the Supplier or DSO is applying implicit demand-side flexibility through (for example) Time-of-Use or kWmax tariffs, the ESCo can provide energy optimization services based on these tariffs. Unlike the (role of) Aggregator, the ESCo is not active (nor exposed) to wholesale or balancing markets.

Bibliography

[1] European Commission, "Analysis of the final compromise text with a view to agreement (11 January 2019), 15150/1/16 REV 1," in *Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on common rules for the internal market in electricity (recast) - 2016/0380(COD)*, Brussels, 2019.

[2] USEF, "USEF White Paper - Flexibility Value Chain 2.0," Arnhem, 2018.

[3] USEF, "USEF - The Framework Explained," Arnhem, 2015.