Aggregators today and tomorrow
From intermediaries to local orchestrators?

Poplavskaya, Ksenia; de Vries, Laurens

DOI
10.1016/B978-0-12-819951-0.00005-0

Publication date
2020

Document Version
Final published version

Published in
Behind and Beyond the Meter

CHAPTER

5

Aggregators today and tomorrow: from intermediaries to local orchestrators?

Ksenia Poplavskaya[1,2] *and Laurens de Vries*[2]

[1]**AIT Austrian Institute of Technology GmbH, Vienna, Austria** [2]**Delft University of Technology, Delft, the Netherlands**

5.1 Introduction

Rapid changes in the electricity sector are creating new challenges and opportunities for market participants. In the European Union (EU), these changes are underpinned by three trends forming the centerpiece of the EU's energy policy:

- Decarbonization drives growing expansion of renewable energy sources (RES) in the electricity grid and markets.
- Decentralization is supported by the push for consumer empowerment and the new opportunities on the demand side.
- Digitalization enables new solutions to connect and coordinate system elements and stakeholders across supply, demand, and grid levels, as further described in Chapter 3.

These trends foster the emergence of aggregators and position them as key enablers that can help unlock value from in front of and behind the energy meter, for example, by pooling consumer loads and small-scale generation or enabling prosumer entry to electricity markets. Yet, so far, their market entry has been a mixed success in the EU countries. The range of value streams that are available to aggregators, consumers and prosumers depends on technical prerequisites, such as availability of smart meters and appropriate communication infrastructure, and also on the market design and the regulatory framework, which create opportunities along with challenges for aggregators.

This chapter reviews the current business models of European aggregators and, based on an assessment of their drivers and barriers, describes how these models may evolve. It

Behind and Beyond the Meter
DOI: https://doi.org/10.1016/B978-0-12-819951-0.00005-0

then identifies three future value streams for aggregators that would allow them to further exploit the potential of local flexibility options. While this analysis is focused on the EU, similar considerations apply elsewhere: the three underlying trends mentioned above are universal, yet, specific value streams available to aggregators elsewhere will depend on the applicable regulation.

The chapter is organized as follows:

- Section 5.2 describes existing aggregators, their main functions, benefits, and unique selling points.
- Section 5.3 provides the big picture of an aggregator's business model environment. It describes current enabling factors and barriers along with the recent changes in the EU regulatory framework.
- Section 5.4 gives a comprehensive overview and analyzes business models of 26 well-known aggregators across the EU.
- Section 5.5 turns toward the future and explores new opportunities and possible business models for aggregators and the changes required to bring them about followed by the chapter's conclusion.

5.2 The roles of aggregators

A real boost to aggregators in the EU was given by the formal acknowledgment of the crucial role of aggregators in the future electricity markets in the Clean Energy for All Europeans Package (hereafter EU Clean Energy Package), a set of directives and regulations that were adopted in 2018–19. The EU defines an independent aggregator as "a market participant that combines multiple customer loads or generated electricity for sale, for purchase or auction in any organized energy market <...> that is not affiliated to a supplier or any other market participant" [Directive 2019/44/EU, 2019; Art. 2(14–15)]. This leaves a lot of room for aggregators to define their business models.

An aggregator is expected to perform an important social function of empowering consumers and small-scale generators and facilitating their access to the markets. One might argue that if markets were perfect, there would be no need for aggregators. However, in practice, aggregators can perform several functions and even though competitive and transparent markets would allow a more diverse spectrum of providers, aggregation would still remain relevant.

Various studies show that end users generally show a low interest in active management of their assets (cf. Lund et al., 2016). Aggregators' ability to connect their customers' assets to the market at minimal transaction costs is one of their most important *raisons d'etre*. The key consists in using advanced automation solutions to extract value from customer flexibility without affecting their comfort levels or operations.

Second, most demand-side providers would otherwise not enter electricity markets or provide system services since generating value with one's flexibility requires complex decision-making to evaluate different options. It involves a high technical expertise and business acumen to generate meaningful gains. Moreover, it inevitably involves a high administrative and operational effort as well as exposure to market risks. Therefore, even with perfectly

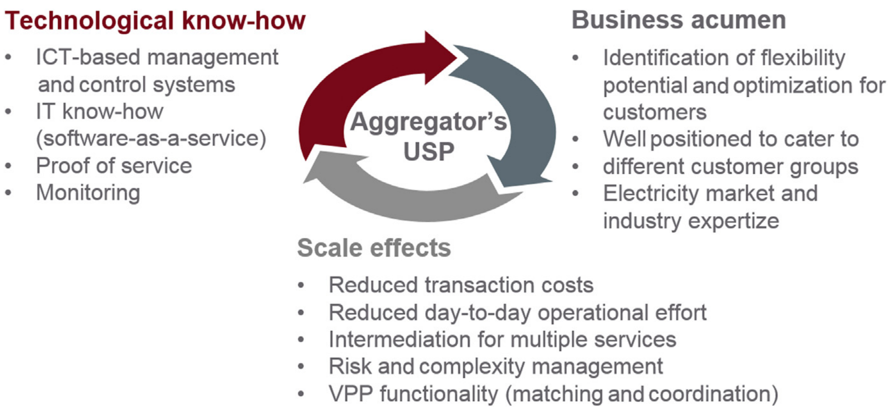

FIGURE 5.1 Technological know-how, business acumen, and scale effects form an aggregator's unique selling points.

accessible markets, these actors would be left at the market fringe. Aggregation in turn is a low-margin business; hence, it requires scale and volume to be profitable.

A third benefit is the pooling of resources. In a balanced portfolio, multiple technologies can help overcome each other's technical constraints. As individual small units cannot provide a meaningful system service precisely due to their limited scale, it requires IT knowledge and an advanced communication infrastructure, something that an aggregator brings to the table. This also allows an aggregator to effectively exploit scale effects and thus reduce transaction costs and mitigate risks for individual participants. The value of aggregators stems from their potential to bundle not only different load or generation sources but also different value streams from multiple activities.

The removal of transaction costs through information and communication technology (ICT) solutions, the business acumen, and the benefits of scale effects form an aggregator's unique selling points (USP), as is shown in Fig. 5.1.

Aggregators do not only cater to end users and distributed energy resources (DER), but combine business-to-consumer (B2C) services with business-to-business (B2B) solutions. For instance, they may assist balance responsible parties[1] by optimizing their portfolios and thereby minimizing imbalances. They can help transmission system operators (TSOs) to procure balancing services more cost-efficiently and distribution system operators (DSOs) to manage their local constraints and obtain a better overview of flexibility at lower voltage levels. Utilities (retail companies) may use aggregators' software and virtual power plant (VPP) solutions to tap into their customers' demand response (DR) potential and offer them bundled electricity services.

In sum, aggregators perform multiple functions such as information management by identifying flexibility potential, pooling of heterogeneous technologies with the help of control and communication systems, matching flexibility to specific markets and services,

[1] Balance responsible party refers to an entity responsible for managing imbalances of their balancing portfolio, a virtual group of generation and/or load, and settling the imbalances incurred as a result of deviations from their submitted generation and/or consumption schedules.

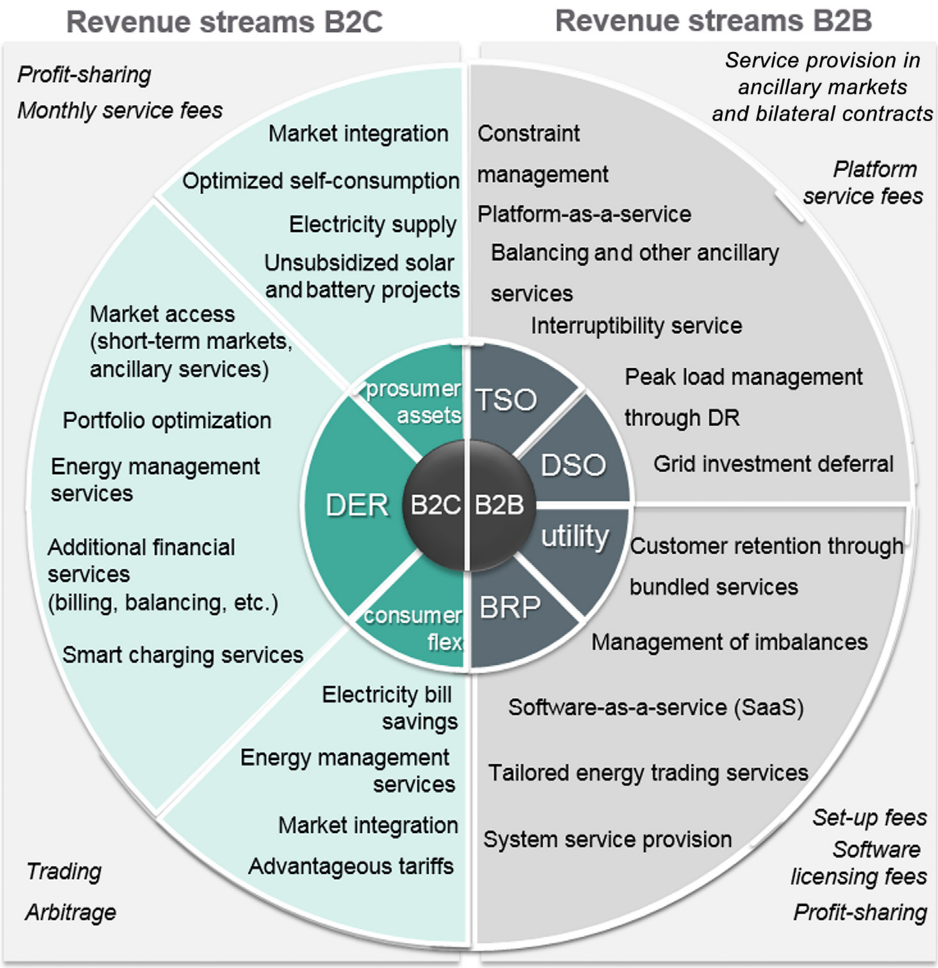

FIGURE 5.2 Potential roles of aggregators, their customer groups (inner circle), value propositions (outer circle), and revenue streams.

and transaction guarantor by bearing responsibility for a reliable service provision (Eid, Codani, Chen, Perez, & Hakvoort, 2015). This position at the intersection of different functions and customer groups creates the intrinsic value of an aggregator role for the system and allows him to obtain several revenue streams. Fig. 5.2 illustrates the roles that aggregators may perform for the various types of actors in the electricity sector. Next to the circle, the main revenue streams in the B2C and the B2B segments are indicated.

5.3 Drivers and barriers

The constraints and enabling conditions that are created by external factors determine the playing field within which an aggregator can develop his business model. The value

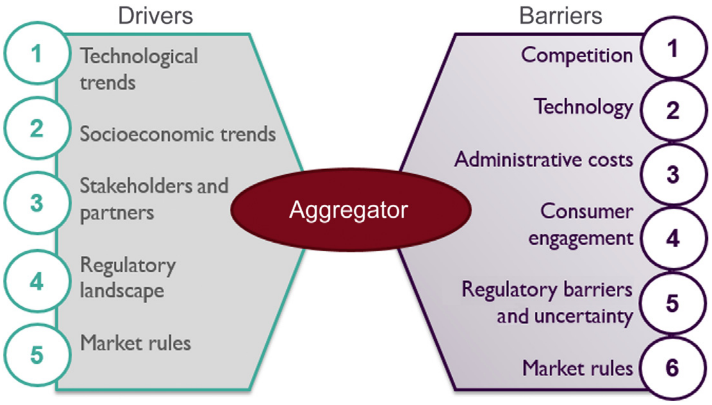

FIGURE 5.3 Drivers and barriers shaping aggregator's business model environment.

that an aggregator can create is a function of the services he can provide and their feasibility in the specific market and regulatory environment. As the latter differs significantly across EU countries, the existing business models are different, too. The factors that shape the external environment can be divided into industry-related factors, regulatory trends, market-related factors, and macroeconomic factors (Osterwalder, Pigneur, & Clark, 2010). This analysis focuses on the first two components to identify current drivers and barriers. Fig. 5.3 provides an overview of the key drivers and barriers, which will be discussed in the remainder of this section.

5.3.1 Drivers

Technological trends: Rapid transformation and decentralization is demonstrated by the intensified use of aggregation or VPP solutions. According to World Energy Outlook 2018, between 2014 and 2017 alone, the volume of aggregation in the EU has grown by over 50% from 12 GW to approximately 18 GW (International Energy Agency, 2018, p. 305). In 2014 utility-owed VPPs accounted for 5 GW as opposed to c. 7 GW of independent third-party owners, whereas in 2017 the volumes amounted to 6 and 12 GW, respectively. About 12.5 GW of the aggregated assets were on the generation side (in the form of VPPs), and 5.5 GW constitutes aggregated demand (International Energy Agency, 2018).

New energy system management tools have opened up opportunities for the demand side, paving the way for prosumers, who are core client segments of aggregators (Fig. 5.2). Electricity itself is only part of the puzzle: other key pieces are communication technology, software and hardware. The aggregator as a new entrant is often more agile and faster at developing technology, which he can either use himself or license to other parties.

Socioeconomic trends: RES-friendly policies and policies encouraging consumer-side participating in the energy system have been shaping the electricity sector. Consumers have been sensitized to the adverse effects of climate change and become aware of the value of environmentally sustainable solutions. “Green solutions” are therefore gaining impetus.

Just like the costs of renewables fell substantially in the past decade, so did the costs of storage. While the development of utility-scale storage facilities slowed down, the installed behind-the-meter (BTM) battery storage capacity grew from a few MW worldwide in 2012 to about 480 MW in 2017 (International Energy Agency, 2018, p. 306), much of this in combination with solar PV.

The stakeholders include not only all types of consumers, prosumers, and small-scale generators but also technology providers and IT companies. Continued success of an aggregator business model relies on smart cooperation across technologies, consumer groups, and industries. This does not only allow exploiting more value sources but also facilitating aggregators' presence in a larger number of countries.

Markets and regulation: The recent adoption of the EU Clean Energy Package galvanized the regulatory landscape in Europe by opening up opportunities for DER and demand to participate in all electricity marketplaces, including ancillary services for the TSO. European short-term electricity markets are being adjusted to account for a growing need for system flexibility, including local flexibility, to offset the challenges of RES integration. As electricity markets become more granular,[2] aggregators not only obtain more trading opportunities for short-term flexibility but also need to determine the value of flexibility in a higher time resolution.

5.3.2 Barriers

The most commonly cited barriers for aggregators and their aggregated resources are formal market entry barriers (Borne, Korte, Perez, Petit, & Purkus, 2018), bid size requirements (Koliou, Eid, Chaves-Ávila, & Hakvoort, 2014; Poplavskaya & De Vries, 2019), restrictions to aggregation (ENTSO-E, 2017), and coordination issues with other market actors (Poplavskaya & De Vries, 2018). In fact, the spectrum of existing hurdles is broader, as is illustrated in Fig. 5.3.

Competition: Incumbent utilities are hot on aggregators' heels, while they often enjoy a better market position along with a well-established customer base. According to Navigant consulting, incumbent strategies include investment, acquisition or partnership with aggregators, technology, and platform providers (Metz, 2018). A number of prominent European supply companies have either engaged in aggregation themselves, for example, Statkraft operates the biggest VPP in Europe, set up or acquired an aggregator, for example, Jedlix is part of Eneco; REstore was acquired by Centrica (see Annex A). Italian Enel acquired a number of companies under its umbrella, a software developer for distributed portfolio optimization, Demand Energy, as well as EnerNOC aggregator (see Annex A) and a provider of charging infrastructure eMotorWerks (Metz, 2018). An example of a supplier-aggregator partnership is an agreement between Innogy and Kiwigrid for joint service development.

Utilities are on the lookout for reliable software platforms to pool consumer renewables and storage assets BTM to tap into the DR potential on a large scale. Platform solutions for market-based service procurement has been under development by both aggregators and software developers as key strategic partners but also are actively explored by utilities such as Enel, Engie, Eon, or Innogy (Metz, 2018). New BTM technologies such as storage,

[2] In Europe, EPEX Spot has a liquid intraday market with both continuous trading and hourly or 15-minute contracts.

energy management solutions, electric vehicles (EVs), and digitalization are also considered as ways for incumbent suppliers to retain customers.

Technology: Smart meters is a prerequisite for successful demand-side management and real-time communication. Although smart meter rollout was mandated by the Electricity Directive, practical implementation in most EU countries has been slow: so far, only a few EU countries, Italy, Spain, and the Nordic countries achieved large-scale rollouts (International Energy Agency, 2018). Smart meter standards and functionalities also vary between countries. Other technical challenges are the connection of different technologies, software standards, and required IT expertise. The status of smart meters is addressed in Chapter 12.

Administrative barriers: Engaging large numbers of small customers is likely to be associated with high transaction costs for marketing and acquisition, contract management, customer retention, support, and customized offers. At the same time, high recruiting costs may chip away at the aggregator's profits as employees are required not only to have a solid industry knowledge but also IT expertise.

Consumer flexibility is likely to raise coordination issues with balancing responsible parties and suppliers they signed a supply contract with. Responsibility for potential imbalances is one of the key issues in the aggregator debate in Europe. As most aggregators do not engage in consumer energy supply, they still rely on a supplier to cover—at least partially—their customers' demand. Decoupling energy supply from sale is complicated: if an aggregator would buy prosumers' energy to take it to the market, this would alter their suppliers' schedule, leading to additional imbalance costs. Unless the information exchanges and settlement rules are clearly specified, aggregators will find it difficult to access demand-side flexibility.

Consumer engagement: Currently, most suppliers agree to offtake and remunerate consumers' self-generated energy at a predetermined tariff, but only if these consumers also have a power supply contract with them. This limits consumers and aggregators in several ways. First, consumers have no choice or control over the price they receive for the self-generated energy. For instance, the tariff received is often lower than the price they have to pay for the energy bought from the supplier and does not correspond to the market price. Second, aggregators are unable to offer their service to such consumers as they are virtually "bound" to the supplier.

Instead through an aggregator, a large customer may also decide to participate in the market itself. If a pricing scheme offered by an aggregator is not attractive enough, a prosumer may accept a buyback payment offered by his regular supplier. In Chapter 9, the authors discuss consumer behavior and mention the limitations of rational decision-making. Limitations in consumer engagement in the Australian context are also addressed in Chapter 15.

Regulatory barriers and regulatory uncertainty: Until recently, the participation of demand, aggregated or not, the use of storage for different services and aggregation itself were formally restricted or even prohibited (ENTSO-E, 2017). A lack of markets for most ancillary services in Europe limits the possibility for aggregators to provide them. Only balancing energy is procured competitively (European Commission, 2017), while markets for redispatch or local constraint management are mostly restricted to pilot projects.

Network tariffs are often overlooked as an important factor. High network tariffs on aggregated consumers or prosumers pose a challenge for aggregators to make attractive offers. In most EU countries the energy component constitutes only about a third of a household bill (ACER/CEER, 2018). As a result, potentially minuscule energy savings may make it difficult to convince future customers. Tariffs are not regulated on the EU level but are determined nationally creating large differences.

Since the directives of the EU Clean Energy Package, which define the market rules for aggregators, still need to be transposed into national legislation, there is regulatory uncertainty, which affects the business models of aggregators.

Market rules: As electricity markets were originally designed for large generation units, their rules often discourage or even prevent the entry of smaller, alternative participants. Barriers for the aggregation business are posed by the authorization of independent aggregation itself or by restrictive rules for the underlying pooled resources and their owners. An example is the limited access of DR to European balancing markets. Stringent technical prequalification is necessary to prove the components' ability to quickly react to control signals. Requirements for VPPs are also different and prequalification procedures need to be conducted for each individual country and have different preauthorization periods. Frequency measurement requirements may further block loads from the balancing market. The main barrier identified by Poplavskaya and De Vries (2018) is unit-based prequalification criteria. Pool-based criteria would ease the compliance not only with the technical requirements but also with the required minimum bid size and an aggregator's ability to reliably provide the service.

With respect to market and regulatory challenges the EU Clean Energy Package and EU Network Codes have significantly improved market access for aggregators and provided a clearer regulatory framework for them and their aggregated portfolios. In Section 5.5, it will be discussed how these changes will create new opportunities for aggregators in the future.

5.4 Overview of aggregator business models

This section reviews the business models of 26 prominent independent aggregators in Europe with respect to their portfolios, geographical coverage, ownership models, value streams, innovation, and focus. The results are summarized in Table 5.1. More detailed information about individual aggregators can be found in Annex A.

The overview shows that aggregators are not evenly distributed across Europe. Aggregator hotspots are located in Germany, United Kingdom, and France, the countries with the highest numbers of national aggregators but also where most aggregators operate with 16, 12, and 10 aggregators, respectively. This points to fairly favorable market rules for aggregators. Other aggregator-friendly countries include Belgium, Switzerland, and the Nordics. In turn, aggregation is very much in its infancy in Southern European countries although the recent opening of electricity markets for aggregation is likely to attract new participants in the near future. For instance, Portugal only recently allowed access to independent third-party aggregators whereas Italy allowed for a pilot project with "virtual qualified consumption or generation units" operated by an aggregator for balancing

TABLE 5.1 Overview of European aggregators according to portfolio, geographical coverage, ownership model, value streams, innovation, and focus (parentheses signify planned or pilot activities).

		A1Energy solutions	Actility	BayWar.e	Ecotricity	energy2market	Energypool	Enelx	Entelios	Enyway	Flexitrcity	Group ASE	Jedlix	KiWi Power	Lichtblick	limejump	Lumenaza	Mark-E	Mobility House	Next Kraftwerke	Noodvermogenpool	Restore	Smart Grid Energy	Sonnen	Sympower	tiko	Voltalis
Portfolio	Generation	✓		✓	✓	✓				✓	✓			✓	✓	✓	✓	✓		✓			✓			✓	
	Demand		✓		✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓			✓	✓	✓	✓		✓	✓	✓
	Storage				✓	✓	✓	✓			✓		✓	✓	✓		✓		✓	✓		✓		✓	✓	✓	✓
Coverage	Main country	AT	FR	DE	UK	DE	FR	US	DE	DE	UK	ES	NL	UK	DE	UK	DE	DE	DE	DE	NL	BE	FR	DE	NL	CH	FR
	More than one country of operations		✓	✓		✓	✓	✓	✓					✓						✓		✓		✓	✓	✓	
Ownership	Owned by a utility (if not, then independent)					✓		✓	✓		✓		✓	✓		✓						✓		✓			
	Originally from a different sector	✓	✓	✓													✓									✓	
Value stream	Asset management and optimization (day-ahead, intraday markets)	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Balancing and other ancillary services	✓	✓	✓		✓	✓	✓	✓		✓		(✓)	✓		✓		✓	(✓)	✓		✓	✓	✓	✓	✓	✓
	Trading			✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓		✓		✓	✓		✓			✓	
	Whitelabel solutions to utilities	✓	✓			✓	✓		✓					✓			✓			✓		✓					✓

(*Continued*)

TABLE 5.1 (Continued)

		A1Energy solutions	Actility	BayWar.e	Ecotricity	energy2market	Energypool	Enelx	Entelios	Enyway	Flexitrcity	Group ASE	Jedlix	KiWi Power	Lichtblick	limejump	Lumenaza	Mark-E	Mobility House	Next Kraftwerke	Noodvermogenpool	Restore	Smart Grid Energy	Sonnen	Sympower	tiko	Voltalis
	DR (commercial and industrial	✓	(✓)		✓	✓	✓	✓	✓		✓	✓		✓	✓				✓	✓		✓	✓	✓	✓	✓	✓
	Household DR														✓									✓			✓
	Electricity supply of end users			✓	✓					✓					✓			✓						✓			
	DSO services			(✓)					(✓)		(✓)			(✓)		(✓)			(✓)					(✓)			(✓)
Innovation	Platform/blockchain/P2P offerings		✓			✓				✓			✓	✓			✓		✓	✓		✓		✓			✓
	Own hardware/software	✓	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓	✓
Focus	Software development	✓	✓			✓	✓		✓				✓	✓		✓	✓		✓	✓		✓		✓		✓	✓
	Customer relationship			✓	✓		✓	✓	✓	✓	✓	✓	✓		✓			✓	✓	✓	✓		✓	✓	✓		✓

AT, Austria; *BE*, Belgium; *CH*, Switzerland; *DE*, Germany; *ES*, Spain; *FR*, France; *IT*, Italy; *NL*, The Netherlands; *P2P*, peer-to-peer; *UK*, United Kingdom; *US*, United States.

market participation (ARERA, 2017). Meanwhile, no aggregators have been spotted in Eastern European countries or in the Baltic States.

The high interest of sector incumbents in aggregator business model is demonstrated by the fact that 35% of all identified aggregators have been acquired or spun off by large utilities in the last few years (see also Annex A). Other aggregators are newcomers with a core business in a different sector such as IT, for example, A1 Energy Solutions, or technology development, for example, battery manufacturer sonnen.

An important observation from Table 5.1 is that there are only a few examples of aggregators that only use demand or generation assets. Most portfolios include flexibility on both the demand and supply sides, such as Next Kraftwerke, further described in Chapter 10. Moreover, 62% of analyzed aggregators pool storage units. Although over two-thirds aggregate demand, 90% of all DR is still provided by commercial and industrial customers (e.g., EnergyPool, Sympower, and Voltalis). BTM aggregation is its infancy: only German Lichtblick, Mark-E, and sonnen are aggregating household DR. Causes range from a lack of information at the consumer level and limited smart-meter rollout to insufficient investment in BTM technologies needed to create a critical mass of flexibility BTM. Yet, these examples show that BTM and upstream options are not mutually exclusive and viable business models can rely on a combination of the two.

The overview demonstrates the importance of value stacking, that is, generating revenue from multiple value streams on the B2C and B2B sides, for an aggregator's long-term profitability. All analyzed business models included a mix of services. All aggregators are involved in asset management and portfolio optimization. Participation in the balancing market remains the most lucrative revenue stream for over two-thirds of aggregators. The IEA reached a similar conclusion (International Energy Agency, 2018, p. 305). A third of the analyzed aggregators are exploring flexibility provision to the DSO. Yet, since there are no well-established mechanisms nor marketplaces for the provision of DSO services, all the projects are in the pilot phase.

Over 85% of the analyzed aggregators use proprietary soft- and/or hardware for VPP operation, for example, Next Kraftwerke's Next Box, KiWi Power's Fruit, and REstore's and Enel X's software, with 73% of the companies offering it as a white-label solution to other market participants. Such hardware and software can be used by asset owners for a more efficient asset management and schedule optimization and by suppliers for VPP operation, reporting and visualization. A reliable forecasting tool for load, RES generation, and market prices is another factor essential for a successful aggregation business and is often integrated in the software. Next Kraftwerke, tiki, and KiWi Power are among the few aggregators that both commercialize energy portfolios in some countries and develop and provide software- or platform-as-a-service, one of their unique selling points (Fig. 5.1) to other market players in countries where market entry is more complicated. For successful consumer engagement, trust in the service reliability is essential. Particularly for BTM aggregation this implies that outside their home market, aggregators are better off playing the role of service providers and partnering with established local market participants.

Business models typically focus on one of three areas:

- infrastructure management,
- customer relations, or
- product and service innovation (Hagel & Singer, 1999).

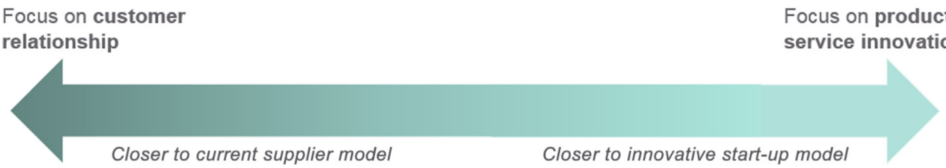

FIGURE 5.4 Aggregator business models can be closer to a traditional supplier or closer to an innovative start-up, depending on whether the main focus is on customer relations or on product and service innovation.

Since in Europe infrastructure management is the prerogative of regulated system operators, aggregators may opt for either of the other two business model types or a combination thereof, which can be illustrated as a scale (Fig. 5.4). The cost structures, value proposition, and revenue streams of a customer-relationship-focused business model are substantially different from a service-innovation model.

Customer acquisition and retention are at the core of the customer-oriented business model and the lion's share of costs stems from marketing and sales. Customer-oriented aggregators compete with incumbent suppliers, even though most aggregators' models do not include electricity supply to final users—only 23% of the analyzed aggregators do (see also Annex A). Customer-oriented aggregators, for example, Flexitricity or Sympower, sell electricity in different marketplaces and offer fixed or dynamic pricing to their—mainly large—customers. Aggregators that focus on product and service innovation have the biggest investment in R&D activities. The main value proposition of aggregators with this model is innovative services. Until recently, product innovation has been a more realistic business model for aggregators due to market entry barriers.

The overview shows that 42% of the analyzed aggregators are exploring new value streams through platform development, Blockchain solutions, and peer-to-peer (P2P) offerings in order to achieve a competitive edge, as further described in Chapter 13. For instance, in exchange for a monthly service charge, EnyWay provides a direct marketplace for consumers and local solar and wind generators to help them switch away from traditional suppliers. EnyWay meets the part of energy demand that could not be covered locally and receives a monthly service charge. Lichtblick provides customers with PV panels dimensioned in a way to cover twice the customer's electricity demand. The customer receives a zero tariff, while Lichtblick sells the other half to the market. Lumenaza offers community management as a service, including Blockchain-based transactions, in addition to traditional energy supply and market positioning of customers' RES. Energy2market also possesses Blockchain expertise, whereas sonnen operates an own platform, sonnenCommunity, for electricity sharing with surplus stored in a virtual electricity pool while offering a special sonnenFlat tariff to flexibility providers.

5.5 New opportunities for aggregators

This section addresses the recent regulatory changes in Europe and how they may impact the business models of aggregators. It will focus on three new trends: energy communities, P2P trading, and the provision of flexibility services for DSOs.

5.5.1 Transformation of the regulatory landscape in Europe

The EU Clean Energy Package and EU Network Codes have made a substantial contribution to regulatory clarity, opening up electricity marketplaces, and creating opportunities for various stakeholders. Most formal barriers to DR and aggregation have been removed: both activities are officially allowed and encouraged (e.g., Directive 2019/44/EU, 2019). The key changes are summarized in Table 5.2 and will be discussed subsequently.

TABLE 5.2 Progress in the European Union (EU) with respect to aggregator business models and value streams.

	Progress	Comments
Short-term wholesale electricity trade		Fully opened to all types of providers, aggregated, or not
		DR formally allowed to participate in the market
		Liquid intraday markets allow flexibility trading close to real time
Balancing markets		Formally opened to all types of providers
		Market rules largely harmonized, balancing products standardized
		Many adjustments to market design are to be implemented before 2021
Incentives for prosumers		Self-generation, consumption and storage are to be encouraged throughout the EU
		As feed-in tariffs are being gradually phased out, stronger incentives for investment in behind-the-meter assets, the optimization of self-consumption, and the involvement of aggregators
		Mechanisms vary nationally (e.g., tax reductions, lower grid tariffs)
Community solutions		Citizen energy communities and renewable energy communities with a broad scope of authorized activities (e.g., shared asset ownership and operation, energy trade) formally introduced in the EU Clean Energy Package
		Rules for peer-to-peer trading platform design and operation remain to be clarified
Network tariffs		Have not been addressed at the EU level; high heterogeneity
		Some tariff reductions for grid-supportive activities exist nationally
		Design of appropriate tariffs for behind-the-meter is urgently needed (see also Chapter 17).
Flexibility for the DSO		DSO is not allowed to own and operate generation assets due to unbundling provisions
		DSOs are encouraged to improve operational efficiency by, e.g., using local flexibility, other than grid expansion, yet no clear mechanisms for procurement
Platform operation		Not explicitly covered in the EU regulation

DR, Demand response; *DSO*, distribution system operators.

The recent developments created opportunities for BTM aggregation. As feed-in tariffs and net metering are being phased out, storage-plus-PV and other BTM flexibility options such as electric boilers and heat pumps offer alternatives for customers to reduce costs by maximizing consumption from own generation. Consumers can also generate revenue by participating in the wholesale and balancing markets or in local trading through an aggregator. Both options are enabled by the EU Clean Energy Package, and a few aggregators have been exploring these value streams (see Section 5.4). The need for system flexibility, especially local flexibility, has been growing strongly. It is likely to continue to increase as higher RES shares increase short-term market volatility and create network congestion. New patterns emerging on the local level in Europe are covered in Chapters 6 and 11.

The EU Clean Energy Package places specific value on community-based solutions. Arrangements in which electricity can be produced, consumed, and shared locally have already been successfully tested in a number of European countries. For instance, Germany implemented its "tenant electricity model" (Mieterstrommodell) that allows landlords to supply tenants with green electricity through an aggregator, for example, German Enyway. Spain has passed its ambitious Royal Decree on Self-consumption in May 2019, both individual and collective (Ministry for the Environmental Transition, 2019). For the first time the package also authorizes P2P trading, which can open up an opportunity for an aggregator as a platform provider. These changes create a chance for an aggregator to turn into a local orchestrator by becoming a community or local flexibility market operator or by offering solutions for P2P trade for prosumers with their BTM assets.

5.5.2 Energy communities

On the consumer side a combination of solar PV with BTM storage or EVs can allow consumers to use self-generated energy more flexibly and to sell their stored electricity at the time when electricity market prices are more attractive. The BTM volume of storage is expected to increase by a factor of 38 in 2025, as compared to 2015, according to Navigant Research (2019).

The EU Clean Energy Package provides for a new approach to consumer participation, which goes beyond the level of individual households. So far, households have been rarely profitable enough for aggregators to make it part of their business models, largely due to a low flexibility volume and often cumbersome arrangements with other market parties (see Section 5.3.2). The focus has now shifted to community-based solutions, which allow aggregators to lower their transaction costs and also to provide different solutions to such communities. The 2019 EU Electricity and the Renewable Energy Directives formalize the concepts of "citizen energy communities" (CEC) and "renewable energy communities" (REC), which are aimed at generating more value locally and at facilitating community-based consumption, sharing and sale of locally produced electricity (Directive 2018/2001/EU, 2019; Directive 2019/44/EU, 2019).

The main features of a CEC include "voluntary and open participation" along with "environmental, economic, or social community benefits" as their *primary* goal. Neither the Electricity nor Renewable Energy Directive limits the area of activities that such communities can undertake. For a CEC, these include “generation, including from renewable sources, distribution, supply, consumption, aggregation, energy storage, energy efficiency services or charging services for electric vehicles” [Electricity Directive, Art 2 (11)].

As a legal entity, an energy community requires a representative. This can be an elected individual or a group of individual shareholders as in the case of a cooperative. An aggregator could represent a CEC or REC in the markets. According to the Directives, the community must maintain its “effective” control for a local economic and environmental benefit, that is, retain the decision-making power. This means that an aggregator acts as a facilitator, responsible for remote control, billing, and use for market participation or grid service provision. Shared use of bulk resources such as a large standalone PV system, battery storage, or a fuel cell could be more attractive than multiple units at individual premises. Another point for an aggregator is that consumers or prosumers will not likely engage in trading and monitoring on a continuous and long-term basis. The first community initiatives show that a lack of sector know-how and IT expertise—two of the main aggregator’s unique selling points (Fig. 5.1)—makes it difficult for communities to set up an economically sustainable model (e.g., Dijkstra, 2019).

Educating consumers about the new options that are provided for energy communities by the recent changes in EU legislation is both a challenge and a prerequisite. Community solutions require incentives for consumers to invest in storage technologies and other DER. Such incentives have so far been rather offered by suppliers but may similarly be offered by aggregators. The issues linked to launching energy community projects are further addressed in Chapters 4 and 6.

Importantly, a community scheme would require an aggregator to take over electricity supply and balancing for the community as long as multiple suppliers are not possible within the same community. The aggregator could charge a monthly service fee for its operations or offer community members a beneficial electricity tariff while being in charge of the remaining supply that a community cannot cover locally. Another option would be to set up a profit-sharing scheme with the community where an aggregator is in charge of providing community resources to different markets and services, and the community is able to select its degree of flexibility and level of risk exposure.

Some countries have already eased the conditions for aggregators and active customers. The most recent amendment of the German Renewable Energies Act foresees that prosumers may sell electricity without a supplier license as long as they do so locally as part of the “direct sale” mechanism [Erneuerbare-Energien-Gesetz (EEG), 2017, 2019]. The UK regulator, Ofgem, together with the market operator, Elexon, are investigating the concept of “rapid supplier switching,” which would allow procurement of energy from multiple suppliers (ELEXON, 2018). Current market liberalization rules foresee that a consumer may switch supplier at any time. “Rapid supplier switching” involves contracts with several actors at the same time but using their services at different times. The EU regulation does not cover such an option. This arrangement would require a supplier to share his responsibility for a customer’s metering point with (an)other market participant(s), for example, a customer’s neighbor through a community scheme or an aggregator. Elexon, however, recognized that “the main” supplier should be notified to keep track of energy feed-in and withdrawal to ensure that a supplier does not incur imbalances through other actor’s actions.

The financial attractiveness of community-based solutions requires adjustments to the network tariffs. Customers who consume energy locally reduce network stress and may be entitled to lower grid tariffs. For instance, in Austria, the DSOs already started offering reduced network tariffs to energy communities exchanging self-generated energy locally as these minimize the use of the higher voltage levels of the network. Another example from Switzerland is presented in Chapter 3.

The main challenge for an aggregator may be to ensure a sufficient scale. This is why it will remain important that an aggregator offers community solutions only as one of its value streams. The example of the German aggregator sonnen, which successfully set up sonnenCommunity with prosumers, achieved scale by connecting prosumers all over the country. This may mean that to ensure a sufficient scale an aggregator may want to connect multiple communities to extract sufficient value.

5.5.3 Peer-to-peer trading platforms

Energy communities have the option to engage in P2P trading, an example thereof is described in more detail in the Chapter 4. P2P trade is in fact rarely pure, as it tends to make use of the public electricity network. As EU law discourages the building of parallel infrastructure—though does not prohibit it (Van Soest, 2018), peers who trade with each other will still use a DSO's network. Although BTM activities, generation, storage, or sharing was often possible, it tended to exclude the use of the public network rendering community-level P2P trade impossible. Therefore, the main hurdle to a number of prosumers jointly owning and operating a set of PV panels, EVs or a battery storage unit in most EU countries has so far been either lack of legal clarity or outright prohibition.

The EU Clean Energy Package has improved the situation as its provisions can be interpreted to authorize the sale of self-produced electricity regardless of the type of marketplace, organized or P2P. The Renewable Energy Directive Art. 21.2(a) allows the so-called renewables self-consumers to engage in "P2P arrangements." It specifies that P2P trading implies "the sale of renewable energy between market participants <...> either directly between market participants or indirectly through a certified third-party market participant, *such as an aggregator*" [emphasis added] (Art. 2(18)). Indeed, the accounting process, coordination, and balancing still needs to be assisted by a market participant, such as an aggregator.

Transaction platforms are essential enablers of sharing economy (Van Soest, 2018) and are crucial to operationalize P2P trade, monitor and log the exchanges, and automate transactions. Aggregators, many of whom already offer platforms-as-a-service, are well-positioned to offer P2P-enabling solutions, either individually or in partnership with suppliers. The viability of this model is confirmed by the fact that of the aggregators identified in Section 5.4 (Table 5.1), Lumenaza already offers P2P solutions.

Some of the questions concerning P2P trade remain unanswered. For instance, if prosumers decide to go beyond business as usual and sell their production directly to other consumers, they would still be obliged to obtain a supplier license, which requires administrative effort and costs that are too high for households or small commercial customers. The Electricity Directive states that the rights and obligations of a CEC "should apply in accordance with the roles that they undertake, such as the roles of final customers, producers, suppliers or distribution system operators" (Preamble (46) of the Electricity Directive). This provision implies that supplier obligations apply as long as commercial gain is considered the main purpose. This is where an aggregator can help. So far, the schemes where P2P traders do not require a license have mostly been confined to pilot and demo projects, usually combined with grid support services. Besides being mentioned in the Renewable Energy Directive, P2P trade was not directly addressed on the EU level, which can create practical issues and differences in national implementation.

The question of what amounts to commercial activity is more difficult to answer and the only aspect that is clear is that P2P trade is assumed to be conducted by two non-professional private consumers. Yet, it does not, and should not, exclude some sort of profit-making (Van Soest, 2018). Remember that not only households but also commercial customers may engage in P2P trade. A need to make a distinction between different prosumer types, for example, those who occasionally sell their excess energy to a neighbor and "intensive prosumers" who intentionally over-dimension their units with the purpose of market participation, will likely arise (Sia Partners, 2018). The distinction may perhaps be made based on the volume that a renewables self-consumer feeds into the grid, or on the ratio between this volume and his own consumption.

Aside from the CEC context, nothing precludes P2P-trading participants from forming a virtual pool of customers in different locations, which creates a stronger case for an aggregator to operate such a platform. An aggregator may be able to make better use of multiple small BTM resources. Several solutions have already been tested—mostly in pilot projects—such as Blockchain technology and other transaction platforms. At least four of the aggregators reviewed in this chapter are conducting trials of Blockchain applications. Blockchain solutions are also addressed in the Chapter 13. Customizable smart contracts can help take aggregation one step further: they simplify data management, allow dynamic review of transactions, allow prosumers signal their intention to deliver a service, and automatically award transactions. Yet, uncertainty as to how Blockchain and internet of things (IoT) might be regulated in the future, especially with regard to data protection, might delay commercialization.

The success factors of this model are described in Section 5.5.1. The treatment of prosumers engaging in P2P trade as suppliers remains to be clarified along with the design of P2P platforms. Furthermore, if P2P traders are indeed considered suppliers, the licensing procedures must be clarified along with the issue of electricity supply from several suppliers (suppliers, aggregators, and peers).

Consumers' main priorities are ease of use, financial security, and reliability of a service provider (see also Chapter 7). For an incoming aggregator, it is easier to develop a partnership with a trustworthy existing national supply company. This can help to cleanly delimit their activities from those of a supplier and create added value for all participants. In such a model the aggregators' revenue streams may be based on licensing fees and periodic service fees.

5.5.4 Local flexibility for the DSO

European DSOs are particularly affected by the growing shares of small-scale RES at lower network levels. At the same time, they can also benefit from the emerging demand

and supply-side flexibility in the distribution grid. As, due to unbundling requirements, DSOs are not allowed to operate electricity generation and storage themselves, procurement of flexibility from third parties, either bilaterally or through designated marketplaces, may be a solution. Currently, there are aggregators who mostly provide ancillary services to TSOs for balancing purposes. Designated DSO marketplaces have so far been nonexistent. Voltage control is usually provided on a mandatory basis without remuneration (Merino et al., 2016). For this reason, besides balancing, the aggregators that were reviewed in Section 5.4 only participated in pilot projects for constraint management. The business potential in the provision of local flexibility is, for instance, indicated by the takeover of the German aggregator energy2market by one of the largest European utilities, Électricité de France (EDF), which estimated the European flexibility market at 200 GW today and double of this volume in 2030.[3]

Transposing the main features of the multisided platform business model, as presented by Evans, Hagiu, and Schmalensee (2008), to an aggregator case, platform-as-a-service can facilitate interaction among different interdependent customer groups, thereby contributing to a more efficient system operation. This business model is gaining traction in numerous sectors thanks to advancements in information technology. In the electricity sector, 14 out of 26 aggregators already offer platform solutions to utilities and system operators, for example, Voltalis, Restore and KiWi Power. With the aid of an advanced communication infrastructure an aggregator may assist a DSO in voltage control, utilizing free network capacities more efficiently, and shaving off or shifting load peaks.

One of the prerequisites for the success of this business model is a sufficient number of members of one customer group, in this case consumers and prosumers, to ensure participation of other customer groups, such as system operators. This often leads to the need to "subsidize" the first group to attract the second group, which is the main source of revenues for the aggregator. There are a number of ways in which aggregators can "subsidize" consumers and prosumers, such as a free app, energy management tools, or free use of the platform. For instance, tiko and Voltalis provide a free app to customers whereas Jedlix and Mobility House developed their own apps for EV owners (see Annex A).

Some of the concerns that the activities of aggregators raise among existing stakeholders is that they may cause network stability issues and increase imbalance costs for suppliers. An aggregator-operated platform can overcome these concerns by sharing information with other actors and, for example, by supporting system operators to efficiently communicate system constraints. This approach could also help to turn existing suppliers from competitors into partners.

The most recent approaches to market-based procurement of system services for the DSO involved the creation of a dedicated platform or a so-called flexibility market. Main drivers were existing European market operators, EPEX and Nordpool. The former is testing a platform, the EPEX Flexibility Marketplace, in Northern Germany as part of the Enera project which brings together RES operators and VPPs on the one side and system operators on the other side. The main traded product is the "variation of one's consumption or generation profile for each 15-minute period of the day" (EPEX SPOT, 2019). Nordpool partnered with a Nordic supplier, Agder Energi, to set up the NODES platform.

[3] https://www.pv-magazine.com/2019/06/14/edf-to-acquire-energy2market/

Entelios is an aggregator that participates in the NODES platform; more aggregators are expected to join (Deuchert, 2019). Yet, an aggregator could operate such a local platform itself as well, as he can provide the main functions: identifying flexibility, pooling resources using own hardware and software and providing flexibility for multiple value streams. The recent experience from the United Kingdom in implementing a platform for trading flexibility is described in Chapter 11.

The multisided platform is the core of the value proposition in this model in which the aggregator's main activities would include identification of flexibility potential, platform management, and operation. The aggregator would act as a market operator or "matchmaker" and charge transaction fees. Revenue streams are obtained primarily from B2B customers in the form of set-up and service fees for platform operation, while a critical mass of customers on the other side make the aggregator an indispensable binding tissue for the local system.

So far, platforms are not regulated in the EU. The main challenge to this model is to design and test such a platform-based market, which requires a close cooperation between aggregators and DSOs. However, if the main design rules for platforms are not regulated at the EU level, a high level of heterogeneity among local platforms can be expected, creating difficulties for the participants.

Regulators are pushing DSOs to consider non-wires alternatives before allowing network upgrades, which may foster aggregation and optimization of BTM loads. A UK platform for trading flexibility is described in Chapter 11. A prerequisite for the successful operation of a platform then lies in providing sufficient incentives for DSO(s) to use the platform. Those DSOs that are subject to CAPEX-based regulation may have little incentive to use flexibility markets instead of usual reinforcement measures. Markets catering to the DSO should therefore be formally established and promoted as a means of more efficient network operation.

The analysis above shows that aggregators are most likely to generate more value than costs by capturing and monetizing multiple value streams and catering to multiple customer groups (Fig. 5.2). Obtaining value from multiple sources makes an aggregator less reliant on a particular customer group or activity. Many of the barriers described in Section 5.3 are being gradually lifted thanks to, among others, the adoption of the EU Clean Energy Package, Network Codes, and individual national initiatives.

This discussion, together with the summary in Table 5.2, highlights the issues that still need to be organized or regulated so that more aggregators can find profitable niches. As aggregators are already actively engaged in portfolio optimization and software development, they are well-positioned to harvest value from local resources, either through community solutions or flexibility platforms. These value streams can be exploited in addition to optimized consumption, which is the main driver and a prerequisite for value stacking. It is necessary that the individuals give their permission to use the aggregated resources not only for local trading but also for market operations of an aggregator. This also offers more financial benefits to the participants in the aggregated community pool or flexibility platform.

Aggregators can help to move the sector beyond the traditional mentality of considering electricity in terms of kWhs that are fed into the grid by large companies and withdrawn by consumers. A focus on consumers shifts this view, first toward service and later toward solution-oriented thinking. This is especially true because the shares of BTM technologies are rapidly growing allowing aggregators to offer bundled services. However, the margins appear to be razor-thin, hence scale is critical to profitability.

5.6 Conclusion

Recent changes in technology, regulation, and market design affect the business models of aggregators. This chapter identified new ways in which these business models may evolve and deliver value for aggregators' customers and energy system as a whole. The analysis of the drivers and barriers to their market penetration were underpinned by a critical assessment of the state of European electricity sector regulation, national examples, and a broad overview of business models of 26 European aggregators. Their number will most likely grow given the emergence of prosumers and the growing need for system flexibility, although it is not certain whether they will remain independent. The attractiveness of the aggregator business is high enough for the incumbents to integrate it in their existing activities, as was shown in the analysis in this chapter.

Five factors have so far helped established independent aggregators to maintain a foothold in the market:

- active marketing strategy combined with a positioning as a branch and IT expert;
- speed of innovation and business model agility, that is, adjustment of the business model given the national regulatory context and the needs of the sector;
- value stacking, that is, deriving value from multiple streams and customer groups;
- strategic partnerships that allowed aggregators to expand their activities into new countries; and
- aggregators' own active participation in shaping the policy dialogue and regulatory framework.

These factors will remain relevant in the future as demand for local flexibility continues to grow.

Whether an independent aggregator manages to carve out a niche for himself further depends on the country conditions and the chosen combination of value streams. Their relevance is seen to be growing not only as electricity market participants but also as providers of specialized service offerings for other actors, software-as-a-service, and platform-as-a-service enter the market. The development of community-based solutions, P2P trade, and local energy markets may help aggregators position themselves as local orchestrators.

This chapter explored three future value streams for an aggregator enabled by the recent regulatory changes in the EU and the factors for successful commercial evolution. Through offering their services to local energy communities, aggregators can provide sector knowledge along with technical and financial expertise for such communities to develop. As a facilitator of P2P trade, an aggregator can enable automated transactions, optimized local energy use, and generate savings for consumers. Finally, as a multisided platform operator, an aggregator can provide a service to the DSO and a chance to consumers or small generators to profit from their flexibility. For these models to be successful and replicable, a number of issues such as purchase of electricity from multiple sellers and network tariff schemes must be revised, and more specific rules guiding local energy solutions and P2P trade, the roles and responsibilities involved, as well as the design of multi-sided platforms must be addressed in regulation in more detail.

Whether provided by an independent market player or by an incumbent participant, aggregation is core to the future development of the electricity sector allowing to integrate BTM solutions into the systems and activate consumers.

Acknowledgment

The authors would like to thank Aby Chacko (tiko), Stephan Marty (KiWi Power), and Matthias Dilthey (sonnen) for the discussions that contributed to this chapter.

References

ACER/CEER. (2018). *Annual report on the results of monitoring the internal electricity and gas markets in 2017—Electricity and gas retail markets volume* (p. 35). Agency for the Cooperation of Energy Regulators and the Council of European Energy Regulators. Retrieved from <https://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Publication/MMR%202017%20-%20RETAIL.pdf>.

ARERA. (2017). Delibera ARERA 372/2017/R/eel—Approvazione regolamento relativo al progetto pilota per la partecipazione della domanda al MSD. In *Pub. L. No. 372/2017/R/EEL*.

Borne, O., Korte, K., Perez, Y., Petit, M., & Purkus, A. (2018). Barriers to entry in frequency-regulation services markets: Review of the status quo and options for improvements. *Renewable and Sustainable Energy Reviews*, *81*, 605−614. Available from https://doi.org/10.1016/j.rser.2017.08.052.

Deuchert, B. (2019). NODES − A new market design to trade decentralized flexibility. In *Presented at the Grid service markets symposium*. Lucerne, Switzerland. Retrieved from <https://gsm450601838.files.wordpress.com/2019/07/g0405-is09-20190704-nodes-gsm.pdf>.

Dijkstra, J. (2019). Ameland: frontrunner in the energy transition. Presented at the Grid Service Markets Symposium, Lucerne, Switzerland. Retrieved from <https://gsm450601838.files.wordpress.com/2019/07/g0201-is15-presentatie_zurich_3-7-2019_without_movie.pdf>.

Directive 2018/2001/EU. (2019). Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (recast). *OJ L 328*, 82−209, 21.12.2018.

Directive 2019/44/EU. (2019). Directive (EU) 2019/44 of the European Parliament and of the Council of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU (recast). *OJ L 158*, 125−195, 14.06.2019.

Eid, C., Codani, P., Chen, Y., Perez, Y., & Hakvoort, R. (2015). Aggregation of demand side flexibility in a smart grid: A review for European market design. In *Presented at the 2015 12th International conference on the European Energy Market (EEM 2015)*. May 19, 2015, Lisbon, Portugal. <https://doi.org/10.1109/EEM.2015.7216712>.

ELEXON. (2018). *Enabling customers to buy power from multiple providers* (p. 8). ELEXON. [White paper]. Retrieved from <https://www.elexon.co.uk/wp-content/uploads/2018/04/ELEXON-White-Paper-Enabling-customers-to-buy-power-from-multiple-providers.pdf>.

ENTSO-E. (2017). *Survey on ancillary services procurement, balancing market design 2016* (p. 222). ENTSO-E. Retrieved from <https://www.entsoe.eu/Documents/Publications/Market%20Committee%20publications/WGAS_Survey_final_10.03.2017.pdf>.

EPEX SPOT. (2019). Local flexibility markets: Beyond the status-quo. In *Presented at the Grid service markets symposium*. July 2019, Lucerne, Switzerland. Retrieved from <https://gsm450601838.files.wordpress.com/2019/07/g0401-is08-epex_spot_local_flexibility_gsm-luzern_04072019.pdf>.

Erneuerbare-Energien-Gesetz (EEG). (2017, 2019). Gesetz für den Ausbau erneuerbarer Energien (Renewable Energies Act, amendment of 2017). In *BGBI. I S.706*.

European Commission. (2017). Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing. *OJ L 312*, 6−53.

Evans, D. S., Hagiu, A., & Schmalensee, R. (2008). *Invisible engines: How software platforms drive innovation and transform industries*. Cambridge, MA: MIT Press.

Hagel, J., & Singer, M. (1999). *Unbundling the corporation. Harvard Business Review*. Boston, MA: Harvard Business School Publishing, March-April issue.

International Energy Agency. (2018). *World energy outlook*.

Koliou, E., Eid, C., Chaves-Ávila, J. P., & Hakvoort, R. A. (2014). Demand response in liberalized electricity markets: Analysis of aggregated load participation in the German balancing mechanism. *Energy*, *71*, 245–254. Available from https://doi.org/10.1016/j.energy.2014.04.067.

Lund, P., Nyeng, P., Duban Grandal, R., Sorensen, S.H., Bendtsen, M.F., le Ray, G., ... Mac Dougall, P.A. (2016). EcoGrid EU – A prototype for European smart grids. In *Deliverable D6.7. Overall evaluation and conclusion* (p. 92). Energinet.dk.

Merino, J., Gomez, I., Turienzo, E., Madina, C., Cobelo, I., & Morch, A. (2016). *Ancillary service provision by RES and DSM connected at distribution level in the future power system (no. D1.1)*. Project SmartNet. Retrieved from <http://smartnet-project.eu/wp-content/uploads/2016/12/D1-1_20161220_V1.0.pdf>.

Metz, A. (2018). *European utilities have increased their activity in new energy platforms*. Navigant Research. <https://www.navigantresearch.com/news-and-views/european-utilities-have-increased-their-activity-in-new-energy-platforms-part-1> Retrieved 02.05.19.

Ministry for the Environmental Transition. (2019). Real Decreto 244/2019, de 5 de abril, por el que se regulan las condiciones administrativas, técnicas y económicas del autoconsumo de energía eléctrica. In *Pub. L. No. BOE-A-2019-5089*.

Navigant Research. (2019). *Residential energy storage: Advanced lead-acid, flow, and Li-ion batteries for residential applications: Global capacity and revenue forecasts* (p. 40) Washington, DC: Navigant.

Osterwalder, A., Pigneur, Y., & Clark, T. (2010). *Business model generation*. Hoboken, NJ: Wiley.

Poplavskaya, K., & De Vries, L.J. (2018). A (not so) independent aggregator in the electricity market: Theory, policy and reality check. In *Presented at the 15th International conference on the European energy market*. June 27, 2018, Lodz, Poland. <https://doi.org/10.1109/EEM.2018.8469981>.

Poplavskaya, K., & De Vries, L. J. (2019). Distributed energy resources and the organized balancing market: A symbiosis yet? Case of three European balancing markets. *Energy Policy*, *126*, 264–276. Available from https://doi.org/10.1016/j.enpol.2018.11.009.

Sia Partners. (2018). *Peer-to-peer (P2P) energy: A threat or an opportunity for traditional suppliers?* Energy Outlook by sia Partners. <http://energy.sia-partners.com/20180911/peer-peer-p2p-energy-threat-or-opportunity-traditional-suppliers> Retrieved 15.04.19.

Van Soest, H. (2018). Peer-to-peer electricity trading: A review of the legal context. *Competition and Regulation in Network Industries*, *19*(3–4), 180–199. Available from https://doi.org/10.1177/1783591719834902.

Annex A Overview of business models of European aggregators

Name	Country	Specifics	Business model	Portfolio specifics
A1 Energy Solutions https://www.a1energysolutions.at/	AT	Originally telecom company	• Participation in the AT balancing market • Asset management and optimization • Service provider for suppliers (as VPP operator), municipal utilities and energy-intensive industries • Own communication and data management platform using A1 own network suitable for monitoring • Own hardware, grid control (also as white label) • DR (peak load shaving and shifting) • Acts as its own BRP	Pool of CHP plants, small hydro, heat pumps, emergency power generators, wind, biogas, boilers, etc. Industrial DR, private households with adjustable loads (electric boilers, heat pumps as well as batteries or PV panels)
Actility https://www.actility.com/	FR; also operates in BE, NL, UK, DE, IT, etc.	Mostly provider of IoT services	• Utility services (e.g., smart meter applications) • IoT network infrastructure and connectivity solutions: ThinkPark Energy platform • Smart energy management for commercial and industrial customers • Demand response facilitator for grid operators	
BayWar.e. https://www.baywa-re.com/en/	DE; also operates in ES, FR, UK, Scandinavian countries	Spinoff of a trading conglomerate, BayWa	• Optimization of self-consumption for commercial and industrial customers	7000 MW of generation managed worldwide Supply of green electricity to 25,000

(*Continued*)

(Continued)

Name	Country	Specifics	Business model	Portfolio specifics
			• Energy trading services • Collaboration with EPEX operator of EPEX Flexibility Marketplace in a pilot flexibility platform in northern Germany for TSO/DSO services • Electricity supply of end users	corporate and private customers
Ecotricity https://www.ecotricity.co.uk/	UK	Originally, green energy supplier	• Offers a VPP solution to green energy providers (wind, solar, and green gas), consumers, and storage operators • Green electricity supplier for household and business customers	n/a
Energy2Market (e2m) https://www.e2m.energy	Originally from DE; operates in FI, IT, FR, BE, PL, SE, NO, AT; UK	Planned to be acquired by EDF in 2019	• Portfolio manager and VPP operator for generators, switchable loads, and storage • White-label offers to utilities outside DE • Service provider for balancing energy (FCR and FRR products) • Partners with Swytch, Blockchain-based RES data and incentive platform, Blockchain protocol development for RES monitoring	VPP total capacity over 3500 MW (~1200 MW of wind, 1600 MW of biomass, ~633 MW of solar, 90 MW of hydro power); industrial loads and storage facilities
EnergyPool https://www.energy-pool.eu/	Originally from FR; also operates in DE, BE, UK, NO, etc.	Strategic partnership with Schneider Electric	• Demand response aggregator of industrial and large commercial consumers for short-term electricity markets, balancing market and capacity market	4 GW of flexible load, 2 GW of generation assets and DER

(*Continued*)

(Continued)

Name	Country	Specifics	Business model	Portfolio specifics
			• Solution for utilities and system operators: DERMS, and Flexmart VPP platform	
Enel X https://www.enelx.com/en/	Originally: US; also operates in: UK; IT, DE, FR, IR	American EnerNOC acquired by Italian Enel in 2017	• DR aggregator for businesses • Energy management and software provider • Proprietary software for asset optimization; customized energy procurement tools • Capacity auction participation in Ireland	Flexible load, storage, and electric vehicles 217 MW demand response in Ireland's capacity auction
Entelios https://entelios-de-web-test.azurewebsites.net/	DE; also operates in NO, SE, and CH	Acquired by Adger Energi	• Industrial DR aggregation and portfolio management • Flexibility trading on part of the client • Participation in the balancing market and German market for interruptible loads • proprietary Entelios Software Suite and white-label DR-as-a-Service • Cooperates with a flexibility platform operator, NODES, operator to provide DR to German DSOs	Industrial and commercial flexible loads, generation, and storage
Enyway https://en.enyway.com/	DE	Spinoff of Lichtblick	• Prosumer service provider: allows households obtain an own share of a large-scale PV panel for 39€ or 99€ for building costs; Enyway is the operator; Enyway uses Blockchain for assigning shares of PV	Large 1.5 MW PV sharing; operators of 35 solar, wind, and small hydro generators

(*Continued*)

(Continued)

Name	Country	Specifics	Business model	Portfolio specifics
			• Provides and operates an online marketplace for local trading between end users and small-scale RES operators	
Flexitricity https://www.flexitricity.com/	UK	Acquired by Alpiq (Swiss electric utility) in 2014	• Largest UK aggregator of industrial DR • Short-term market trading • Balancing market participation, including short-term operating reserve and capacity market in the UK • Use of Footroom or Demand turn-up to avoid curtailment of wind farms by the TSO • Projects where it provides services for DSOs to refer infrastructure investments	Generation and load: CHP, manufacturing loads, sewage and landfill gas, diesel, small hydro and storage, space cooling and cold storage Portfolio of c. 300 MW
Grupo ASE https://www.grupoase.net/asesor-energetico-grupo-ase/	ES		• Largest aggregator of large-scale industrial and commercial DR in Spain • Portfolio management • Energy service company for large customers	400 large-scale and 1100 medium-scale industrial and commercial clients
Jedlix https://jedlix.com/	NL	Owned by Dutch supplier, Eneco	• Smart-charging platform provider, e-car fleet operator and aggregator, customer app, concludes contracts with car manufacturers • Partners with Next Kraftwerke for TSO services	EV fleet ~6000 cars ~60 MW

(Continued)

(Continued)

Name	Country	Specifics	Business model	Portfolio specifics
KiWi Power/ Kiwigrid https://www.kiwipowered.com/	Originally from UK; also operates in FR, NL, CH, BE, DK, and DE	Engie is a stakeholderoriginally, a technology provider; now focuses on strategic partnerships	• Technology provider (own software and hardware, KiWi Fruit) • Asset management and optimization • Platform-as-a-Service for DER management • Grid balancing, capacity market • Constraint management for system operators • Peak shaving • Service provider for utilities → outside of the UK operates through building partnerships with utilities with local knowledge and expertise • KOMPv2 platform for automated DR • Service provider for other aggregators • Transactive Grid solution (platform) • Flexibility platform operator in Flexhub project • charging pattern optimization/smart charging	>1 GW of connected DER in total; 70 MW of battery systems in the UK, several hundred MW; includes commercial and industrial DR (e.g., from hotel chains, hospitals or industrial customers for AC, heat pumps, refrigeration); bulk and BTM battery storage (for customers with load of 1MW +) and DR, RES, EVs, and charging stations
LichtBlick https://www.lichtblick.de/	DE		• Independent demand aggregator • Product SchwarmEnergie, including battery, EV, heating, and home appliance aggregation • RES supplier of end users using Lichtblick's components: fixed 0€/month consumption tariff	Biggest solar provider (c. 1,000,000 household customers); flexible loads, battery and thermal storage, and distributed generation Supply of electricity from RES to 70,000 commercial and industrial customers

(Continued)

(Continued)

Name	Country	Specifics	Business model	Portfolio specifics
Limejump https://limejump.com/	UK	Energy technology company; acquired by Shell in 2019	• Prequalified participant in UK's frequency response and balancing mechanism • Participation in the UK capacity market • Generation management and forecasting services • Power purchase agreements with RES providers • Project to provide peak load management with batteries for a British DSO	185 MW of energy storage; batteries, chillers, CHP engines, etc.
Lumenaza https://www.lumenaza.de/de/	DE	Software developer	• Platform provider for consumers, suppliers and generators; • Community/P2P trading solutions • "Direct sale" offering to German prosumers • Balancing group management as a BRP • Can act a retail supplier	Projects included aggregation of residential PV and battery storage as well as of wind parks
Mark-E https://www.mark-e.de/	DE		• Electricity supply of end users • Participates in balancing mFRR and aFRR with Mark-E Power Pool of small-scale generation • "Direct sale" offering for RES operators	c. 40% RES; portfolio of 2200 MW 368,000 customers Pool of small-scale generation (of min 500 kW)
Mobility House https://www.mobilityhouse.com/	DE		• EV fleet and load management with own software • optimization of EV charging; V2G solutions	Second-hand car batteries; partners with Nissan: stationary second hand car batteries (13 MWh); 3 MWh

(*Continued*)

(Continued)

Name	Country	Specifics	Business model	Portfolio specifics
			• EV park as mobile storage (project for TenneT DE);—uses Blockchain technology	battery storage sites in NL: 30 MW +
Next Kraftwerke https://www.next-kraftwerke.de/	Originally from DE; also operates in NL, BE, AT, ITA and FR, and CH		• Own software: Next Box • Balancing market participation • Acts as its own BRP • Schedule optimization for asset owners, generators, and consumers • Wholesale market trading with a VPP • In NL partners with AgroEnergy and Tenergy to provide Incidence reserve for the Dutch TSO, TenneT—in NL cooperates with Jedlix for TenneT NL to provide short-term storage from an EV pool • Service provider elsewhere in the world: offers platform/digital solutions for different applications, e.g., NEXTRA (trading and portfolio optimization tool for utilities, BRPs and other aggregators)	c. 6800 MW, 2550 MW of flexibility (c. 7600 units) and over 700 MW of aggregated consumers; RES aggregator in Italy; greenhouse lighting, CHPs or an EV car pool in NL
Noodvermodelpool http://nlnvp.nl/	NL	Acquired by Actility in 2017	• Largest DR aggregator in NL • Prequalified provider of emergency reserve (balancing product) in NL	Includes c. 40 industrial partners from the water industry, hospitals, and data centers

(Continued)

(Continued)

Name	Country	Specifics	Business model	Portfolio specifics
Restore https://restore.energy/en/	Originally from BE; also operates in DE, UK, FR, NL	Acquired by Centrica in 2017	• Energy technology provider • Balancing (FCR and aFRR) and capacity market participation with BTM assets of large industrial and commercial clients; • Service to large customers through proprietary software, FlexTreo. • FlexPond platform solution for utilities	Industrial DR (e.g., steel, paper, chemical industry) 2300 MW of aggregated flexibility
Smart Grid Energy https://www.smartgridenergy.fr/	FR		• Demand-side management of commercial and industrial clients • Asset management and optimization of generation • Participation in the FR balancing and capacity markets	Large flexible industrial and commercial load of c. 600 MW (paper, metal, chemical, cement industries, hospitals, logistics centers); rapid reserves 500 MW. Key figure in capacity mechanisms—1000 MW
Sonnen https://sonnengroup.com/	Originally from DE; also operates in IT, UK	Originally, technology provider (battery manufacturing and EV chargers); acquired by Shell in 2019	• Own technology, sonnenBatterie • Operation of an own platform, sonnenCommunity, for electricity sharing with surplus stored in a virtual electricity pool • Offers a special sonnenFlat tariff to flexibility providers • Aggregated storage used for balancing market participation (prequalified for FCR) • Electricity supply of end users	battery storage: 40,000 household batteries worldwide—300 MWh combined with smart home management

(*Continued*)

(Continued)

Name	Country	Specifics	Business model	Portfolio specifics
			• participates in pilot project of a German TSO, TenneT, for redispatch using batteries and Blockchain • Pilot project for local congestion management in DE	
Sympower https://www.sympower.net/	NL, FI		• Balancing market participation with industrial demand response	Flexible loads (cooling, heating, ventilation, lighting, and water systems)
tiko Energy Solutions https://tiko.energy/	Originally from CH; active in FR, DE, AT	Shareholders include Swisscom, the biggest Swiss telecom company	• DR aggregator/VPP operator • Technology provider (outside CH) • Micro-local management of household electricity equipment • Balancing service in CH (FCR, aFRR) • BRP services • Partners with conventional power plants • In other countries, active through partnerships: • e.g., FCR provision in DE in partnership with Sonnen	>100 MW: heating/cooling, water boilers, batteries, PV, EV chargers, heat pumps
Voltalis http://www.voltalis.fr/	FR		• Largest aggregation platform for DR • Optimization of self-consumption with Voltalis Box • Ancillary services for the TSO • IoT service provider for utilities and DSO • Home energy management solutions and app	Commercial, industrial and also residential DR (100,000 + individuals connected) 1,000,000 connected appliances: water boilers, electric heating systems, air conditioning, batteries, EVs, and solar PV

AT, Austria; *BE*, Belgium; *BRP*, balance responsible party; *BTM*, behind-the-meter; *CH*, Switzerland; *CHP*, combined heat an power; *DE*, Germany; *DERMS*, distributed energy resource management system; *DK*, Denmark; *DR*, demand response; *DSO*, distribution system operator; *ES*, Spain; *EV*, electric vehicle; *FCR*, frequency containment reserve; *FI*, Finland; *FR*, France; *FRR*, frequency restoration reserve; *IoT*, Internet of things; *IR*, Ireland; *IT*, Italy; *NL*, The Netherlands; *NO*, Norway; *P2P*, peer-to-peer; *PL*, Poland; *RES*, renewable energy sources; *SE*, Sweden; *TSO*, transmission system operator; *UK*, United Kingdom; *US*, United States; *V2G*, vehicle-to-grid; *VPP*, virtual power plant.