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Aggregator's Business Models: Challenges Faced by Different Roles

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***Abstract*—Aggregators are considered essential to obtain flexibility from small residential and service sector consumers. They can implement business models by trading flexibility from their consumers' assets in various electricity markets. The aim of this paper is to identify challenges faced by aggregators with different roles, while implementing business models. We consider aggregators possessing three roles: of a supplier, Balance Responsible Party (BRP), and of an independent aggregator. The results show that challenges identified create higher complexity for aggregators with BRP's role and independent aggregators to implement business models, while it is significantly easier for aggregators with supplier's role. Recommendations are given to overcome the higher complexity: standardization of contracts and raising consumers awareness. These recommendations facilitate aggregators with different roles to implement their business models, and enable a healthy competition in electricity markets.**

***Index Terms*—Aggregator, flexibility, business model, electricity market.**

I. Introduction

Balance between electricity supply and demand must be maintained for the reliable operation of the power system. A difference between electricity supply and demand, which is called the system imbalance [1], leads to a deviation from the nominal system frequency, 50 Hertz in Europe. The system imbalance endangers the reliability and stability of the power system [2]. Even though it is necessary to eliminate the system imbalance, renewable energy sources (RES), such as wind and solar, introduce more variability and uncertainty in the power system since RES generation fluctuates over time, and is not possible to predict with high accuracy. This implies that RES result in more difficulties to eliminate the system imbalance.

The power system needs to be able to deal with the variability and uncertainty caused by increasing penetration of RES. This can be achieved through flexibility, which is the ability of power system to adapt its operation in response to variability or uncertainty, by modifying electricity demand or generation [3]. Flexibility can be obtained using several means: dispatchable power plants, demand response, energy storage, and interconnection [4]. Among these flexibility means, demand response and energy storage can be acquired from the demand side of the power system. These have gained noteworthy attention to facilitate the integration of RES in academia, as well as in industry [5].

Flexibility from the demand side can be traded in electricity markets. However, the demand and supply of individual residential and service sectors' consumers are too small to be able to participate in the electricity markets. *Aggregators*, on the other hand, are able to pool and coordinate flexibility coming from the consumers [6], making them rather crucial for successful implementation of flexibility from the demand side [7]. Aggregators can participate in various electricity markets on behalf of their consumers, and can trade flexibility obtained from their consumers' assets. Different actors in the power system can become aggregators, causing aggregators to have different *roles*. For instance, when an existing actor such as supplier becomes aggregator, this is considered an aggregator with supplier's role in this paper.

Aggregators can implement business models by participating in electricity markets [8]–[10]. However, different roles that aggregators have might impact how they implement their business models. In this paper, the aggregators' roles are discussed in relation to their business models. Therefore, the aim of this paper is to identify challenges faced by aggregators with different roles, while implementing their business models. For this purpose, we first analyze different actors which might become aggregators, as well as the contractual agreements they need to have to become an aggregator. Afterwards, we identify challenges that aggregators with different roles experience during implementation of business models. In addition, we also propose recommendations to cope with these challenges.

The remainder of this paper is organized as follows. Sections II and III provide an overview of aggregators' business models and their roles. The contractual agreements required for aggregators are explained in Section IV. The challenges faced by the aggregator's different roles are given in Section V. This is followed by recommendations to address these challenges in Section VI, and conclusions in Section VII.

II. Aggregators' business models

Aggregators can participate in various electricity markets on behalf of the consumers, by using their assets, such as appliances, Electric Vehicles, and battery energy storage systems, to provide flexibility in these markets. By participating in different markets, aggregators can implement business models, with the objective of making profit. The business models that

aggregators can implement can be outlined as follows: trading flexibility in day-ahead market [11], trading flexibility in intra-day market [12], providing power reserves [13], balancing portfolio internally [14], and managing congestion [10].

As pointed out previously, the aggregator aims to make profit with business models. However, this is also true for the consumers; they should also be able to benefit by giving a permission to the aggregator to use their assets. This implies that the aggregator needs to offer financial rewards to the consumers to motivate them. These rewards are agreed through the contracts between the aggregator and the consumers. The relation between the aggregator and the consumers in aggregator's business models is illustrated in Fig. 1. In this paper, it is assumed that the consumers are financially motivated, although different consumer types are studied and classified based on their motivation in the literature. More information concerning this can be found in [15].

Fig. 1. Relations between the aggregator and the electricity markets, and between the aggregator and the consumers, in aggregator's business models

One of the widely used frameworks to analyze business models is the *business model canvas framework* [16]. The framework allows companies to describe and structure their business models more easily. The canvas framework consists of four areas of business, and nine blocks within areas: customer (customer segments, customer relationships, channels), offer (value proposition), infrastructure (key activities, key resources, key partners), and financial viability (cost structure, revenue stream). Since this paper aims to identify challenges for aggregators with different roles while implementing business models, we use the canvas framework to associate the identified challenges with blocks in this framework. Note that this paper does not analyze each business model individually by applying the canvas framework.

III. Aggregators with different roles

Existing actors in the power system, such as suppliers, and Balance Responsible Parties (BRPs), can become an aggregator. A supplier is responsible for purchasing and selling electricity for consumers by trading in electricity markets, particularly in the day-ahead market (DAM). A BRP is responsible for submitting energy programmes that indicate the net energy that is planned to be taken from/fed into the grid for the next day [17]. Any deviation between the energy planned to be taken from/fed into the grid, and actual energy taken from/fed into the grid, is called the individual imbalance of the BRP. The BRP needs to pay imbalance costs for their individual imbalances.

In addition to suppliers and BRPs, an independent actor, not associated with a supplier or BRP, might become an aggregator. It should be noted that Distribution System Operators (DSOs) are also discussed to take up flexibility trading function to become an aggregator. However, based on surveys among European stakeholders in the electricity markets, DSOs are considered least suitable to act as an aggregator [18], due to the fact that they are heavily regulated and cannot perform commercially. Hence, in this paper we do not consider DSOs to be an aggregator.

The main distinction of the aggregator compared to the other actors, such as a supplier and BRP, is their ability to trade flexibility. This is called *flexibility trading function*. In other words, actors which can participate and trade flexibility in different electricity markets are considered to have flexibility trading function. Therefore, suppliers, BRPs or independent actors can take up flexibility trading function to become an aggregator. This is depicted in Fig. 2, where an aggregator can have one of the three roles: (1) supplier's role, (2) BRP's role, and (3) independent aggregator.

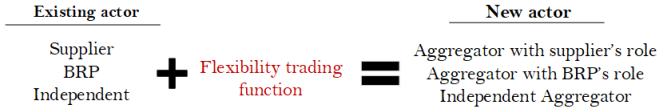

Fig. 2. The process of an existing actor to become an aggregator

IV. Contractual agreements for aggregators

The addition of flexibility trading function necessitates new contractual agreements for the actors, to become an aggregator. It should be emphasized that this paper mainly focuses on the Dutch electricity markets, and hence contractual agreements are given in the Dutch context. These might vary between different countries, depending on their regulations [19].

A. Aggregator with supplier's role

A supplier takes up the flexibility trading function to become an aggregator, demonstrated in Figure 3. In this case, the aggregator is responsible for both buying electricity for the consumers, and trading flexibility obtained from their assets in the electricity markets. It should be noted that it is obligatory for suppliers to have a BRP role, or to have a contract with another company that has a BRP role, in order to trade electricity in the electricity markets. Thus, the supplier has already contracts with a BRP. Since the supplier already has contracts with a BRP and the consumers, they do not require any new contractual agreements, except for making changes in the existing ones, i.e. offering financial rewards to the consumers to be able to use their assets' to trade flexibility.

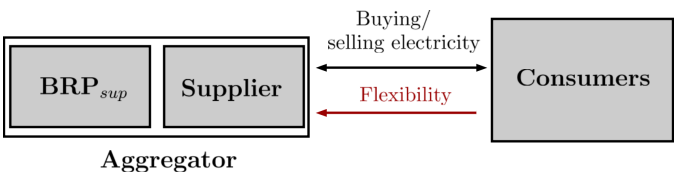

Fig. 3. Overview of an aggregator with supplier's role

B. Aggregator with BRP's role

A BRP takes up the flexibility trading function to become an aggregator, displayed in Fig. 4. This results in two BRPs on the same connection; both the supplier and the aggregator have their own BRPs. Thus, agreements need to be made between the aggregator and BRP_{sup}, as the aggregator's actions might influence the imbalance position of BRP_{sup}. In other words, aggregator's decisions may result in an imbalance for BRP_{sup}. This is explained in more detail in [20].

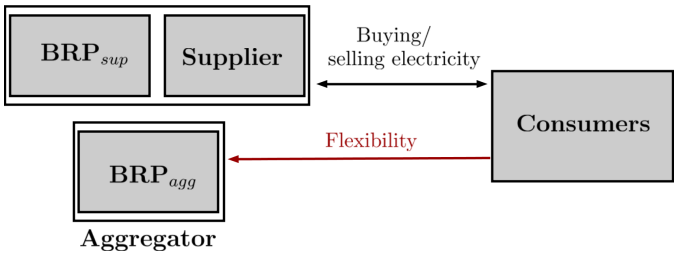

Fig. 4. Overview of an aggregator with BRP's role

The aggregator also needs to have contracts with the consumers to be able to trade their assets' flexibility in electricity markets. Furthermore, another contract between the aggregator and the supplier is necessary since the aggregator might change the supplier's plans on when to use consumers' assets.

C. Independent aggregator

An independent actor which is not affiliated to a supplier or a BRP, when taking up the flexibility trading function, can be defined as an independent aggregator [21]. It is obligatory in the Netherlands for independent aggregators to have contracts with a BRP [19]. This means that an explicit agreement with a BRP is required to allow an aggregator to participate in electricity markets. The independent aggregator's agreement with a BRP can be realized in two ways: (1) having a contract with supplier's BRP (BRP_{sup}), and (2) having a contract with another BRP (BRP_{agg}). These are elaborated below:

1) Independent aggregator having contract with supplier's BRP: By having a contract with BRP_{sup}, the independent aggregator transfers their balance responsibility to BRP_{sup}. This means that there is only one BRP, which is BRP_{sup} at the connection of the consumers. The aggregator also needs to have contracts with the consumers to be able trade their assets' flexibility in the electricity markets.

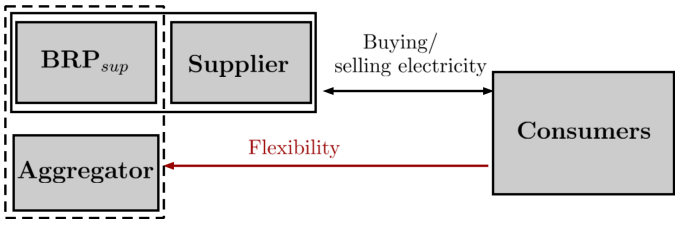

Fig. 5. Overview of independent aggregator having contract with BRP_{sup}

Furthermore, another contract between the aggregator and the supplier is necessary since the aggregator might change the supplier's plans on when to use the consumers' assets, see Fig. 5. Namely, the supplier might submit a bid in the DAM with a certain schedule, based on forecasts of the electricity demand of consumers, RES generation etc. However, the independent aggregator might lead to a change in that schedule by trading flexibility. Hence, the independent aggregator needs to provide a compensation for the supplier's loss.

2) Independent aggregator having an agreement with another BRP: By having a contract with another BRP (BRP_{agg}), the independent aggregator transfers their balance responsibility to BRP_{agg}. This results in two BRPs on the same connection, see Fig. 6. This is similar to the aggregator with BRP's role in terms of contractual agreements, except for the contract between the independent aggregator and BRP_{agg}, as the independent aggregator is not a BRP.

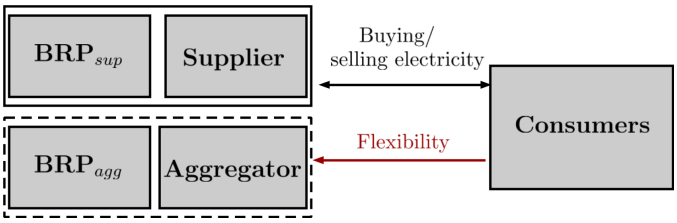

Fig. 6. Overview of independent aggregator having contract with BRP_{agg}

All the contractual agreements needed for aggregators with different roles are summarized in Table I. The cells marked with gray in this table indicate no contractual agreement is needed between the aggregator and the other actor.

V. Challenges faced by aggregators with different roles

Aggregators with different roles face different challenges while implementing a business model. In this section, we address these challenges, which are divided into three main categories: institutional, economic and social challenges.

A. Institutional challenges

Institutional challenges deal with the challenges related to rules and regulations that the aggregators might experience, when implementing their business models. It should be remarked that institutional challenges are not associated with the canvas framework since this framework does not cover regulation area of business model.

1) Number of contracts: As displayed in Table I, it is easier for aggregators with supplier's role to implement their business models, due to the fewer number of the contractual agreements, as opposed to independent aggregators and aggregators with BRP's role.

2) Information exchange: As the number of contracts between the aggregator and the other actors increases, information exchange between them also becomes a serious issue. Actors may need information from the aggregator, in order to enable accurate forecasting or calculating consumers' electricity bills. However, some of this information may contain commercial interests. Therefore, it is essential that the actors agree what information will be disclosed.

TABLE I
CONTRACTUAL AGREEMENTS REQUIRED FOR AGGREGATORS WITH DIFFERENT ROLES. CELLS MARKED WITH GRAY INDICATE NO CONTRACTUAL AGREEMENT IS NEEDED.

Contract with / **Aggregators with different roles**	**Consumers**	**BRP**$_{sup}$	**BRP**$_{agg}$	**Supplier**
Aggregator with supplier's role	Modifications to existing contracts			
Independent aggregator with BRP$_{sup}$				
Independent aggregator with BRP$_{agg}$				
Aggregator with BRP's role				

B. Economic Challenges

Economic challenges deal with the financial obstacles that the aggregators might experience, when implementing their business models.

1) Financial relations with the other actors: The aggregator is interested in making profit when implementing a business model. Therefore, they need to make sure that the business model is economically feasible. In order to assess whether a business model is economically feasible, it is essential to take into account all the financial relations the aggregator has with the other actors, i.e. the payments the aggregator needs to make to other actors. These financial relations may impact the economic feasibility of the business model. For instance, they may cause the business model to be economically infeasible, meaning that the aggregator would not implement it. Not incorporating these financial relations makes the assessment of economic feasibility incomplete, and might lead to wrong conclusions.

For aggregators with supplier's role, the only financial relation is with the consumers, whereas more financial relations are defined for independent aggregators and aggregators with BRP's role. For example, when independent aggregators with BRP$_{sup}$ evaluate the economic feasibility of a business model, they need to consider how much they need to pay to the consumers, as well as the supplier. This challenge corresponds to 'cost structure' in the canvas framework since cost structure describes all cost to implement a business model.

2) Financial reward to the consumers: As already mentioned, an aggregator needs to offer financial rewards to the consumers to be able to use their assets. Nevertheless, it should be underlined that aggregators with different roles might not be able to provide the same financial rewards. For instance, suppliers offer retail price, which is paid by the consumers to the supplier to purchase the electricity. Meaning that aggregators with supplier's role are capable of using the retail price as a financial reward by offering a lower flat-rate retail price, or by offering time-varying electricity tariffs, such as Time of Use, Retail Time Pricing, or Critical Peak Pricing tariff[1].

On the other hand, independent aggregators and aggregators with BRP's role are not able to change the retail prices, and thus to use them as a financial reward. For this reason, they need to offer extra payments as financial rewards. These extra payments can be offered as flat-rate or time-varying prices as well. This challenge also corresponds to 'cost structure' in the canvas framework.

[1]A detailed overview of time-varying tariffs can be found in [22].

C. Social challenges

These concern the consumers' behaviors and preferences. Engaging the consumers in their business models might be a significant social challenge for aggregators with different roles.

Familiarity with existing actors: Consumers have familiarity with actors with whom they already have contracts. This familiarity provides an advantage to these actors, over actors with whom the consumers need to establish new contracts. This means that the consumers might be more inclined to have their supplier as the aggregator, instead of BRPs or independent actors, since only alterations to existing contracts are required with the suppliers, as shown in Table I. This challenge corresponds to 'channel' in the canvas framework since channel deals with reaching customers through different channels, and raising awareness about the company.

VI. RECOMMENDATIONS TO DEAL WITH CHALLENGES

Considering the identified challenges, it can be noticed that it seems to be easier for aggregators with supplier's role to implement a business model, owing to fewer number of contracts, less need for information exchange, option to modify the retail prices, fewer number of financial relations, and the already established contracts with the consumers. Contrarily, independent aggregators and aggregators with BRP's role involve higher complexity. This also coincides with the results from the survey in [18], as the most respondents prefer suppliers to become the aggregator.

This high complexity may cause suppliers to have a more dominating position, and may hinder the participation of BRPs and independent actors as aggregators. As a result, it may prevent a healthy competition in the electricity markets, while it is argued that having independent aggregators is expected to boost competition [19]. Therefore, it is necessary to avoid the development of suppliers' dominating position, by facilitating the participation of BRPs and independent actors. To do so, the following recommendations can be considered:

A. Standardization of contracts

The drawbacks of the high complexity can be solved by establishing standardized processes for the contractual agreements. The following needs to be defined in this process:

- **Financial relations between actors:** How much the aggregator needs to pay to the other actors, and how these payments impact the economic feasibility of the business model should be incorporated.
- **Information exchange.** What information will be shared between actors should be clarified.

Standardizing the contractual agreements enables aggregators with different roles to implement their business models more smoothly, and thus fosters competitive electricity markets.

B. Raising consumer awareness

Raising consumer awareness of the opportunities provided by aggregators with BRP's role and independent aggregators might motivate consumers to engage with actors that they are not familiar with (they do not already have a contract with). For this purpose, offers of these aggregators may be promoted via various mediums such as emails, newsletters, public reports, websites, etc.

VII. Conclusion

This paper identifies institutional, economic and social challenges aggregators with different roles can face, while implementing their business models. These challenges are also associated with the business model canvas framework. It is shown that challenges, such as high number of contracts, the need for information exchange, financial relations between actors, and consumers' familiarity, result in higher complexity for aggregators with BRP's role and independent aggregators to implement a business model, while it is significantly easier for aggregators with supplier's role. Recommendations are provided to solve this high complexity: standardization of contracts and raising consumers awareness. These recommendations facilitate aggregators with BRP's role and independent aggregators to implement their business models, and enable a healthy competition in electricity markets. In this paper, we do not consider aggregators' business models individually. Individual business models can be analyzed by applying the canvas framework. Moreover, it could be a subject for future research to analyze whether aggregators with certain roles are more advantageous in certain business models.

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References

[1] R. A. van der Veen, A. Abbasy, and R. A. Hakvoort, "Agent-based analysis of the impact of the imbalance pricing mechanism on market behavior in electricity balancing markets," *Energy Economics*, vol. 34, no. 4, pp. 874–881, 2012.

[2] B. Shen, G. Ghatikar, Z. Lei, J. Li, G. Wikler, and P. Martin, "The role of regulatory reforms, market changes, and technology development to make demand response a viable resource in meeting energy challenges," *Applied Energy*, vol. 130, pp. 814–823, 2014.

[3] F. Gracceva and P. Zeniewski, "A systemic approach to assessing energy security in a low-carbon eu energy system," *Applied Energy*, vol. 123, pp. 335–348, 2014.

[4] H. Holttinen, A. Tuohy, M. Milligan, E. Lannoye, V. Silva, S. Müller, L. Sö *et al.*, "The flexibility workout: managing variable resources and assessing the need for power system modification," *IEEE Power and Energy Magazine*, vol. 11, no. 6, pp. 53–62, 2013.

[5] F. Shariatzadeh, P. Mandal, and A. K. Srivastava, "Demand response for sustainable energy systems: A review, application and implementation strategy," *Renewable and Sustainable Energy Reviews*, vol. 45, pp. 343–350, 2015.

[6] E. Koliou, C. Eid, J. P. Chaves-Ávila, and R. A. Hakvoort, "Demand response in liberalized electricity markets: Analysis of aggregated load participation in the german balancing mechanism," *Energy*, vol. 71, pp. 245–254, 2014.

[7] K. T. Ponds, A. Arefi, A. Sayigh, and G. Ledwich, "Aggregator of demand response for renewable integration and customer engagement: Strengths, weaknesses, opportunities, and threats," *Energies*, vol. 11, no. 9, p. 2391, 2018.

[8] S. I. Vagropoulos and A. G. Bakirtzis, "Optimal bidding strategy for electric vehicle aggregators in electricity markets," *IEEE Transactions on power systems*, vol. 28, no. 4, pp. 4031–4041, 2013.

[9] Ö. Okur, N. Voulis, P. Heijnen, and Z. Lukszo, "Critical analysis of the profitability of demand response for end-consumers and aggregators with flat-rate retail pricing," in *2018 IEEE PES Innovative Smart Grid Technologies Conference Europe (ISGT-Europe)*. IEEE, 2018, pp. 1–6.

[10] M. R. Sarker, M. A. Ortega-Vazquez, and D. S. Kirschen, "Optimal coordination and scheduling of demand response via monetary incentives," *IEEE Transactions on Smart Grid*, vol. 6, no. 3, pp. 1341–1352, 2014.

[11] X. Ayón, M. Á. Moreno, and J. Usaola, "Aggregators' optimal bidding strategy in sequential day-ahead and intraday electricity spot markets," *Energies*, vol. 10, no. 4, p. 450, 2017.

[12] J. Hu, R. Harmsen, W. Crijns-Graus, E. Worrell, and M. van den Broek, "Identifying barriers to large-scale integration of variable renewable electricity into the electricity market: A literature review of market design," *Renewable and Sustainable Energy Reviews*, vol. 81, pp. 2181–2195, 2018.

[13] I. Lampropoulos, J. Frunt, F. A. Nobel, A. Virag, P. P. van den Bosch, and W. L. Kling, "Analysis of the market-based service provision for operating reserves in the Netherlands," in *2012 9th International Conference on the European Energy Market*. IEEE, 2012, pp. 1–8.

[14] Ö. Okur, N. Voulis, P. Heijnen, and Z. Lukszo, "Aggregator-mediated demand response: Minimizing imbalances caused by uncertainty of solar generation," *Applied Energy*, vol. 247, pp. 426–437, 2019.

[15] J. Paauw, B. Roossien, M. Aries, and O. G. Santin, "Energy pattern generator; understanding the effect of user behaviour on energy systems," in *Proceedings of the 1st European Conference Energy Efficiency and Behaviour, Maastricht, The Netherlands, Oct*, 2009, pp. 18–19.

[16] A. Osterwalder and Y. Pigneur, *Business model generation: a handbook for visionaries, game changers, and challengers*. John Wiley & Sons, 2010.

[17] R. A. van der Veen and R. A. Hakvoort, "The electricity balancing market: Exploring the design challenge," *Utilities Policy*, vol. 43, pp. 186–194, 2016.

[18] A. Muhaimin, "Electricity market of the future: assessing economic feasibility and regulatory constraints for demand response aggregators in Europe," *Master thesis*, 2015.

[19] P. Bertoldi, P. Zancanella, B. Boza-Kiss *et al.*, "Demand response status in EU member states," *Brussels, Belgium*, 2016.

[20] H. de Heer and M. van der Laan, *USEF: Workstream on Aggregator Implementation Models: Recommended Practices and Key Considerations for a Regulatory Framework and Market Design on Explicit Demand Response: Update 2017: Includes Residential Customer Segment*. USEF, 2017.

[21] European Commission, "Proposal for a directive of the european parliament and of the council on common rules for the internal market in electricity," 2016.

[22] N. G. Paterakis, O. Erdinç, and J. P. Catalão, "An overview of demand response: Key-elements and international experience," *Renewable and Sustainable Energy Reviews*, vol. 69, pp. 871–891, 2017.