IMPACT OF AN AGGREGATOR OF DISTRIBUTED ENERGY RESOURCES ON TRADITIONAL POWER SYSTEM PARTICIPANTS

Ivan Pavić
University of Zagreb, Croatia
Ivan.pavic@fer.hr

Mateo Beus
University of Zagreb, Croatia
Mateo.beus@fer.hr

Hrvoje Pandžić
University of Zagreb, Croatia
Hrvoje.pandzic@fer.hr

Tomislav Capuder
University of Zagreb, Croatia
Tomislav.capuder@fer.hr

Ivona Štritof
Hrvatska elektroprivreda d.d., Croatia
ivona.stritof@hep.hr

Ivan Andročec
Hrvatska elektroprivreda d.d., Croatia
ivan.androcec@fer.hr

ABSTRACT

The main idea of our paper is to analyze business models for aggregators and to determine the best options for implementation in small power markets with low levels of liquidity and competition, such as Croatian power market. The research question we are trying to tackle is: if the flexibility from distributed energy sources is going to be used on those markets, which traditional power system participants are going to affected?

INTRODUCTION

High penetration of renewable energy resources requires higher flexibility levels compared to traditional power systems based on fossil fueled thermal and hydro power plants. A possible way to increase flexibility in decarbonized power system is to activate distribution system users. Since distribution system users, or distributed energy sources or DERs (in the context of their active roles), are manly too small to participate in different power markets (especially short-term markets such as day-ahead, intraday, and balancing markets) they should be aggregated under wholesale entity which can efficiently sell their flexibility in these markets, e.g. under aggregators. European Commission nourishes the idea of unlocking the flexibility through aggregators which can be seen in the Winter Package of energy measures published a year ago [1], [2], [3].
To summarize, detail review of aggregators' business models and market concepts will be presented in the paper. Advantages and disadvantages of different models will be compared for all current power system participants. As a final thought, the guidelines for implementation of different models will be provided.

DISTRIBUTED ENERGY RESOURCES AND AGGREGATORS

DERs can be defined by their possibility to generate, store or controllably consume electricity, i.e. by direction of their power and flexibility provision. In general, there are three different DER types:

- Unidirectional DERs – consumption:
  - Energy efficiency,
  - Demand response: implicit and explicit,
- Unidirectional DERs – generation:
  - Controllable distributed generation (fossil fueled – fossil DG, hydro, geo, biomass, biogas – RES DG),
  - Distributed combined heat and power – CHP,
  - Variable renewable energy resources distributed generation – VRES DG,
- Bidirectional DERs:
  - Distributed energy storage – DES,
  - Electric vehicles – EV,
  - Active consumers or prosumers – combination of different consumption, generation and storage technologies on different levels [4]: residential prosumers, energy communities, commercial and public prosumers.

Wide range of DER technologies lead to wide range of DER aggregators definitions. As it can be seen on Figure 1, aggregators for specific DER technology usually do not participate on the same markets. When aggregators are defined in the context of variable RES such as small photovoltaics or wind turbines, they sell their electricity on long or short-term DAM markets. Since VRES are inflexible in their nature (stochasticity of wind and sun), they are not used as flexibility providers on balancing markets, but as flexibility sinks on IDM. Distributed energy storage, stationary DSE or within EVs, require an aggregator that can efficiently buy/sell their energy on short term markets (energy arbitrage) or offer their flexibility to balancing markets (ancillary services).
On the other side of the power balance equation, we can se that conventional consumer suppliers are defined in a similar manner as VRES aggregators. Conventional suppliers buy electricity for their inflexible consumers on long or short-term DAM markets. If consumers integrate demand response, generation or storage technologies on their installations they become active consumers or prosumers. Prosumers still require its suppliers to acquire bulk energy for them, however, since they have possibility to inject the power to the grid and to respond to grid/market signals they also need an entity that can offer such flexibility to power exchange or grid operators. Such an entity could be part of suppliers' activities or independent entity aggregating just demand response (or storage or generation) technologies.

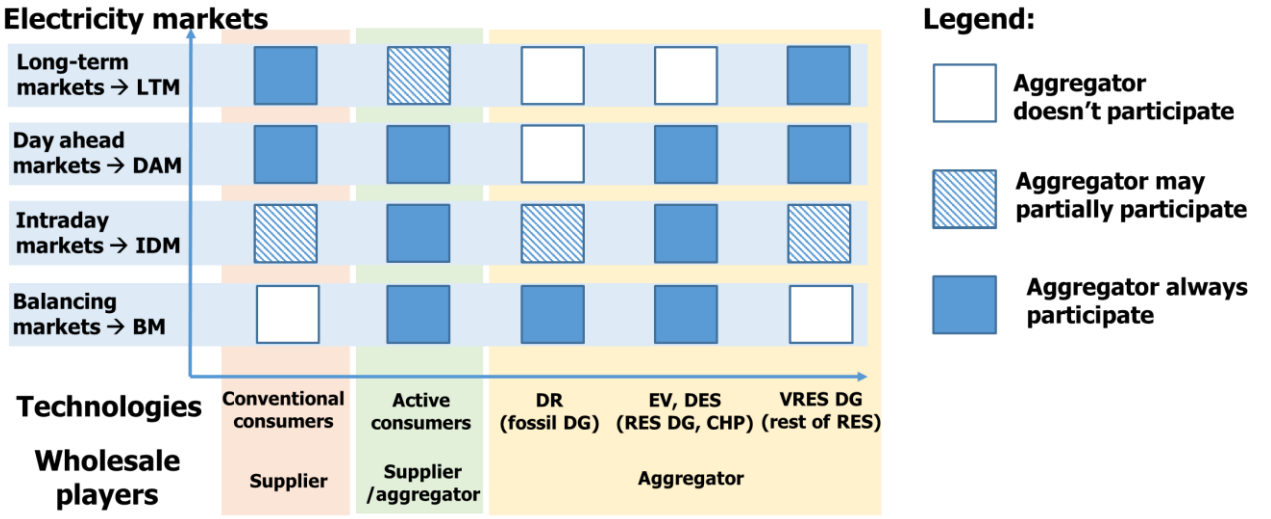

Figure 1 Different Aggregator definitions for different DERs

If independent aggregator observes only DR within consumers facility, then it will operate on balancing market and partially on IDM where he will sell consumers flexibility. At the same time supplier will by bulk electricity for the same consumer.

It can be concluded that collision between supplier and aggregator can occur at some point and that some of the participants can experience monetary losses. Therefore, next Section will define possible aggregator models and point out their weaknesses and strengths.

AGGREGATOR MODELS

Four general aggregator models can be defined, as it is presented on Figure 2, [5], [6]:

- Supplier/aggregator: one entity on different markets, suppliers provide bulk energy supply and aggregation service for flexibility provision.
- Independent aggregator: two wholesale entities for one consumer, supplier provide bulk energy supply wile aggregator provides flexibility aggregation services, two submodel groups:
  - Without balance responsibility: aggregator is not a member of any balance responsible party group and it doesn't have obligation to send day-ahead plans to system operator.
  - With balance responsibility: aggregator must be a member of balance responsible party group and it have obligation to send day-ahead plans to system operator. Two submodels:
    - Without imbalance corrections: there is no financial remuneration from aggregator to supplier if aggregator causes imbalances to supplier. In other words if a flexibility provider is called to provide balancing service he is not exempted from imbalance pricing.
    - With imbalance corrections: there must be financial remuneration from aggregator to supplier if aggregator causes imbalances to supplier. In other words, if a flexibility provider is called to provide balancing service he is exempted from imbalance pricing.

Advantages of supplier/aggregator model are the easiest implementation to current market and balancing scheme and minimal legislation and regulation changes. On the other hand, countries with smaller number of retail companies will not feel any changes when it comes to liquidity and competitiveness increase. Majority of financial inflows for such companies will still come from energy supply which can lead to negligence of aggregation services. Active increase in aggregation services and flexibility can decrease electricity prices (especially in peak periods) which also dissimulate such companies to find more distributed flexibility providers.

Advantages of independent aggregator model in smaller countries with insufficient number of retailers can be increase in electricity market participants, i.e. competitiveness increase. Also, specialized companies for DER aggregation and flexibility provision will appear which can lead to more efficient system and market operation. The main disadvantage is required major legislative and regulation changes.

The main advantage of independent aggregator which doesn't have balance responsibility is simplicity when entering market as a new company but on the other hand it distorts current market and balancing scheme so other participants can be financially damaged.

Independent aggregator with balance responsibility but without imbalance corrections is again characterized with implementation simplicity. However, if an aggregator must pay to system operator for imbalances it causes when it provides balancing services to the same system operator then it doesn't have financial incentive to enter the market. This model is not sustainable.

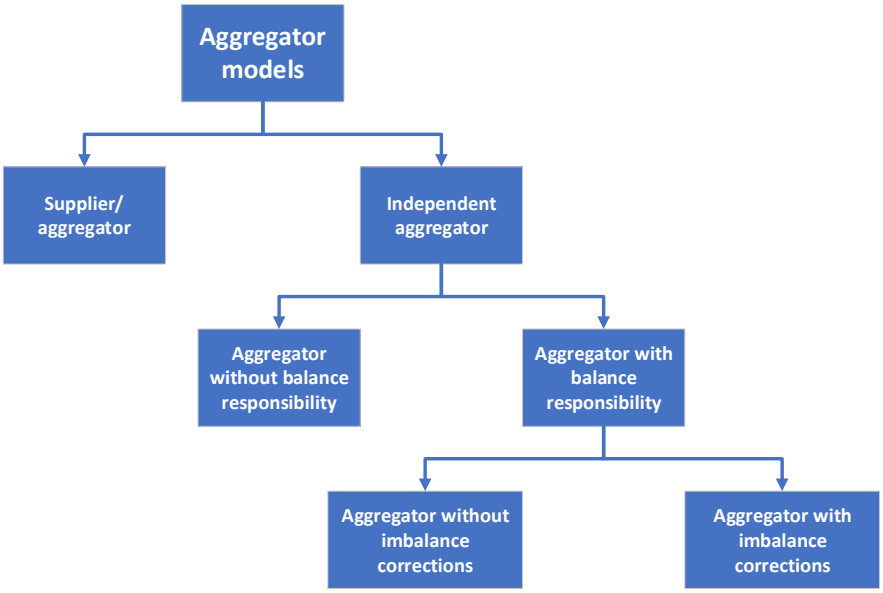

Figure 2 Observed aggregator models

Independent aggregator with balance responsibility and with imbalance corrections have the financial incentive to start operation. The main disadvantages is how to calculate compensation form aggregator to supplier? Also, how will the imbalances be evidented if aggregator and supplier are in two different BRP groups.

TRADITIONAL PARTICIPANTS ATTIDUTE TO AGGREGATION SERVICES INTRODUCTION

Based on pros and cons from the last Section, two models have been identified as possible to implement into today's power market and balancing schemes: supplier/aggregator and independent aggregator with balance responsibility and imbalance corrections. Both of those models provide financial incentives to provide aggregation services.

Each power markets consists of the following regulated participants connected with grid or market operation:

- Transmission system operator TSO,
- Distribution system operator DSO,
- Energy (electricity) market operator,
- Electricity exchange operator,
- Energy (Electricity) regulating agency,
- Universal, last resort supply.

Also, there are wholesale market participants directly connected with power systems:

- Electricity generating companies,
- Electricity supply companies,
- Energy (electricity) service companies ESCO,

Form the retail side:

- Consumers/prosumers,
- Industrial consumers,

The supporting industries:

- Software development companies,
- ICT companies,
- Equipment producing companies.

Power system participants can benefit from aggregation services integration as aggregation/flexibility providers and as aggregation/flexibility users. Detail impact on traditional power system participants is illustrated on Figure 3. Unlocking additional flexibility by activation of traditionally passive system participants means opening the door to a more efficient electricity trading, which can lead to lower prices and higher quality of services. New companies designated to specific new services, such as demand response, can decrease energy bills for their clients. Still, some of the dominant traditional energy companies can experience monetary losses if the aggregators enter the market

Both transmission and distribution system operators can benefit from integration of aggregation services. Since they are regulated companies, they cannot be aggregators, but they can use cheaper services. Number of companies offering flexibility services (such as ancillary services) will increase and the price can decrease.

Big electricity suppliers have access to many customers. If they take the role of aggregators, they can improve their market position and attract new customers. At the same time, the aggregation can negatively affect monetary inflow from their core activity, i.e. supply of electricity, due to lower prices. The second issue concerning electricity suppliers and their role as aggregators is: how well can they dedicate to activities of aggregation? Revenues from aggregation are relatively low compared to those of electricity supply, which can lead to neglection of aggregation in favor of supply. Supply companies can provide aggregation services in supplier/aggregator model and can benefit from additional financial inflow, but if independent aggregator model is adopted then aggregator can cause imbalances to them and it can bring them additional cost.

Conventional electricity producers (thermal, hydro power plant operators) are yet another important power system participants directly affected by aggregation.

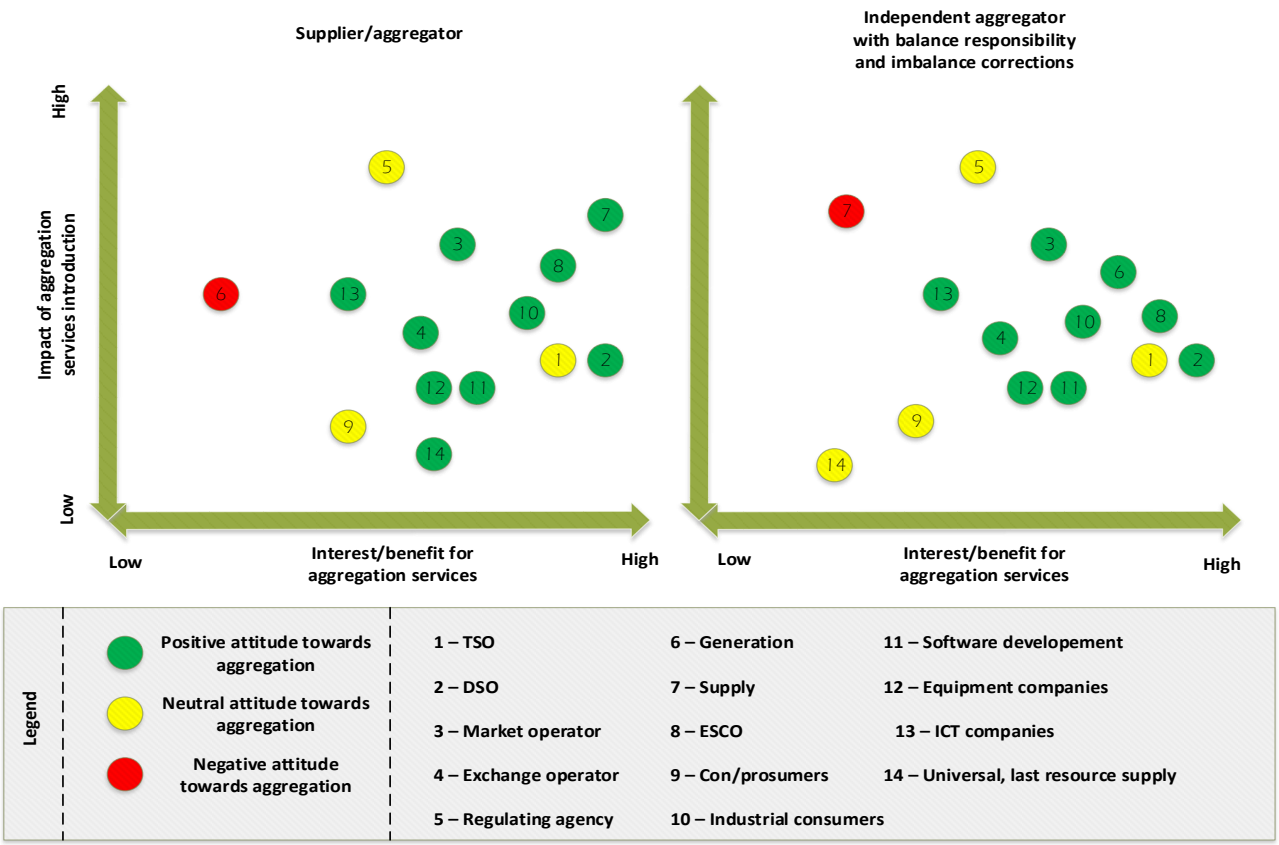

Figure 3 Impact of implementation of aggregation services on traditional power system participants

They do not benefit from lower electricity prices nor from higher competition in the ancillary services market due to aggregation appearance. However, electricity producers can benefit if some current obligations are removed from their power plants (e.g. obligation of primary reserve provision by conventional power plants in Croatia) and they can sell their capacity on more profitable markets. Generation companies can also suffer from monetary losses is additional flexibility services appear because they can lose their market share (today such companies provide all needed flexibility). On the other hand, in independent model they can also provide aggregation services and create new business opportunities. Last resource companies do not have neither opportunity neither new cost connected with aggregation. ESCO companies are ideal for aggregation services because they have knowledge concerning smart metering which is the base for aggregation services. All other mentioned companies, institution and industries can only benefit form new business models.

CONCLUSION

Aggregation of DERs is a necessity in low-carbon power systems and it will be implemented in some way. Each power system has its own characteristic and the model should be chosen by their thorough examination. The induces cost should be minimal, whereas the social welfare should be increased as much as possible

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