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

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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 system participants are going to be affected?

INTRODUCTION

High penetration of renewable energy resources requires higher flexibility levels compared to traditional power systems based on the 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 a wholesale entity, e.g. under aggregator, which can efficiently sell their flexibility in these markets.. European Commission nourishes the idea of unlocking the flexibility through aggregators which can be seen in the Winter Package of energy measures proposed a year ago [1], [2].
To summarize, a detail review of aggregators' business models and market concepts will be presented in the paper. Advantages and disadvantages of different models will be evaluated for the current power system and market 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 & explicit,
- Unidirectional DERs – generation:
  - Controllable distributed generation (fossil fueled – fossil DG, hydro, geo, biomass, biogas – RES DG),
  - Distributed combined heat and power,
  - 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 [3]: residential prosumers, energy communities, commercial and public prosumers.

A wide range of DER technologies leads to a wide range of DER aggregators definitions. As it can be seen on Figure 1, aggregators for a specific DER technology usually do not participate on the same markets. When aggregators are defined in the context of VRES such as small photovoltaics or wind turbines, they sell their electricity on the 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 (undispatchable generation increase flexibility requirements). Distributed energy storage, stationary DES or EV, 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 see that conventional consumer suppliers are defined in a similar manner as VRES aggregators. Conventional suppliers buy electricity for their inflexible consumers on the long-term or 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 most of the 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, balance responsible parties or grid operators. Such an entity could be part of suppliers' portfolio or an independent entity aggregating just demand response (or storage or generation) technologies.

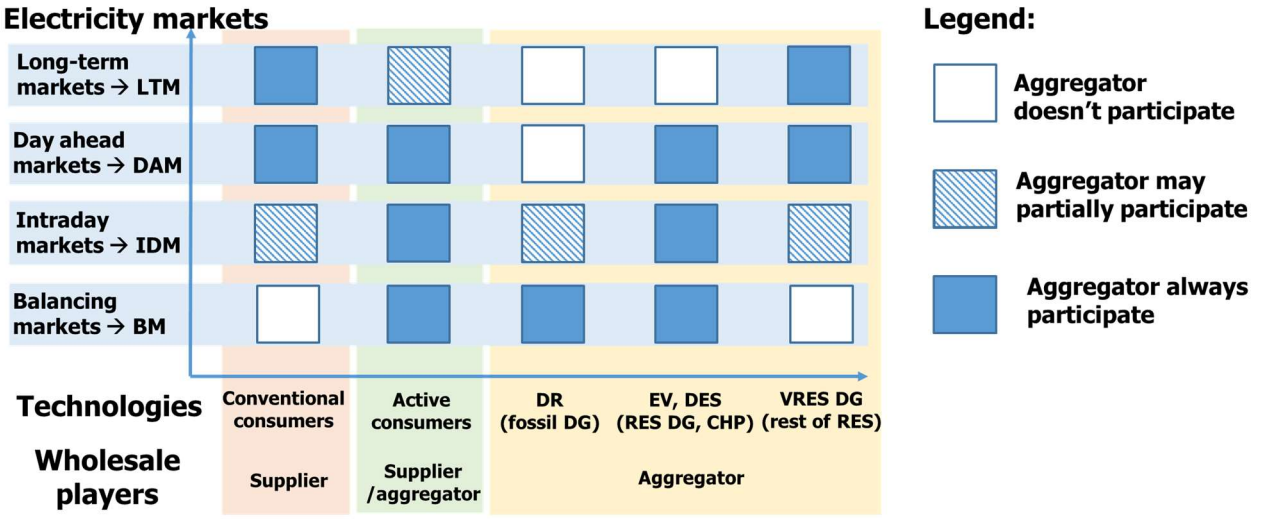

Figure 1 Different Aggregator definitions for different DERs

If an 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 buy 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 (green boxes), [4], [5]:

- Supplier/aggregator: one entity on different markets, suppliers provide energy supply and aggregation service for flexibility provision.
- Independent aggregator: two market entities for a single consumer, a supplier provides energy supply wile aggregator provides flexibility aggregation services, two submodel groups:
  - Without balance responsibility: aggregator is not a balance responsible party and it doesn't have an obligation to send day-ahead plans to system operator.
  - With balance responsibility: aggregator must be a balance responsible party and it has an 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. If a flexibility provider is called to provide balancing he is exempted from imbalance pricing.
    - With imbalance corrections: there is financial remuneration from aggregator to supplier if aggregator causes imbalances to supplier. If a flexibility provider is called to provide balancing he is not exempted from imbalance pricing.

Advantages of supplier/aggregator model are easy implementation in a current market and balancing scheme and minimal legislative and regulatory changes. On the other hand, markets with small number of retail companies will not feel any changes when it comes to liquidity and competitiveness increase. Majority of revenues 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 disstimulate such companies to contract active consumers as flexibility providers. Advantages of independent aggregator model for small markets with insufficient number of retailers can be increase in market competition and development of new business models in terms of technologies and services. 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 a deep comprehensive change in legislative, regulatory and market design. The main advantage of independent aggregator which doesn't have balance responsibility is simplicity and low costs when entering market as a new entrant 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 a system operator for imbalances it causes then it doesn't have a financial incentive to enter the market, which makes this model unsustainable.

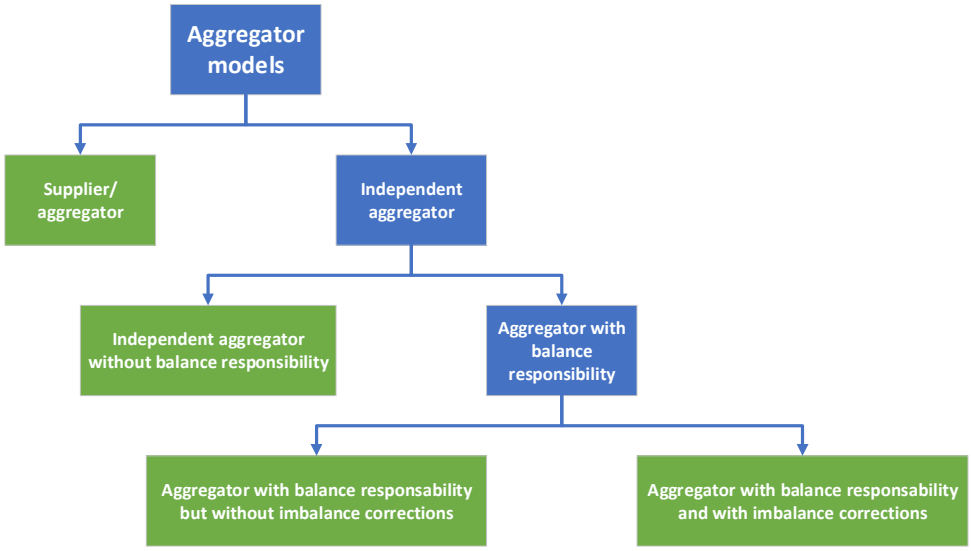

Figure 2 Potential aggregator models

Independent aggregator with balance responsibility and with imbalance corrections has the financial incentive to enter a market. The main disadvantage of this aggregator model is a question how to calculate compensation costs between the aggregator and supplier. Also, a question arises how the imbalances will be settled if aggregator and supplier are in two different balance responsible 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 these models provide financial incentives to provide aggregation services.

Each power market consists of the following regulated participants:

- Transmission system operator TSO,
- Distribution system operator DSO,
- Energy (electricity) market operator,
- Electricity exchange operator,
- Energy (Electricity) regulating agency,
- Last resort supplier.

Also, there are wholesale/retail market participants:

- Electricity generating companies,
- Electricity supply companies,
- Energy (electricity) service companies ESCO,
- Consumers/prosumers,
- Industrial consumers,

The supporting industries:

- Software development companies,
- Communication companies (ICT),
- Equipment producing companies.

Power system participants can benefit from aggregation services integration as aggregation/flexibility providers and as aggregation/flexibility users. A 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, they cannot be aggregators, but they can use cheaper services or reduce their investment costs. As a number of companies offering flexibility services increase consequently the price of these services and the cost of grid losses 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 revenues from their core activity, i.e. supply of electricity, due to lower prices and lower profit margin. The second issue concerning electricity suppliers and their role as aggregators is: what is their incentive to focus on 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 business. Supply companies can provide aggregation services in supplier/aggregator model and can benefit from additional revenues, but if an independent aggregator model is adopted then aggregator can cause imbalance settlement and possibly bulk energy costs to them causing additional profit losses.

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

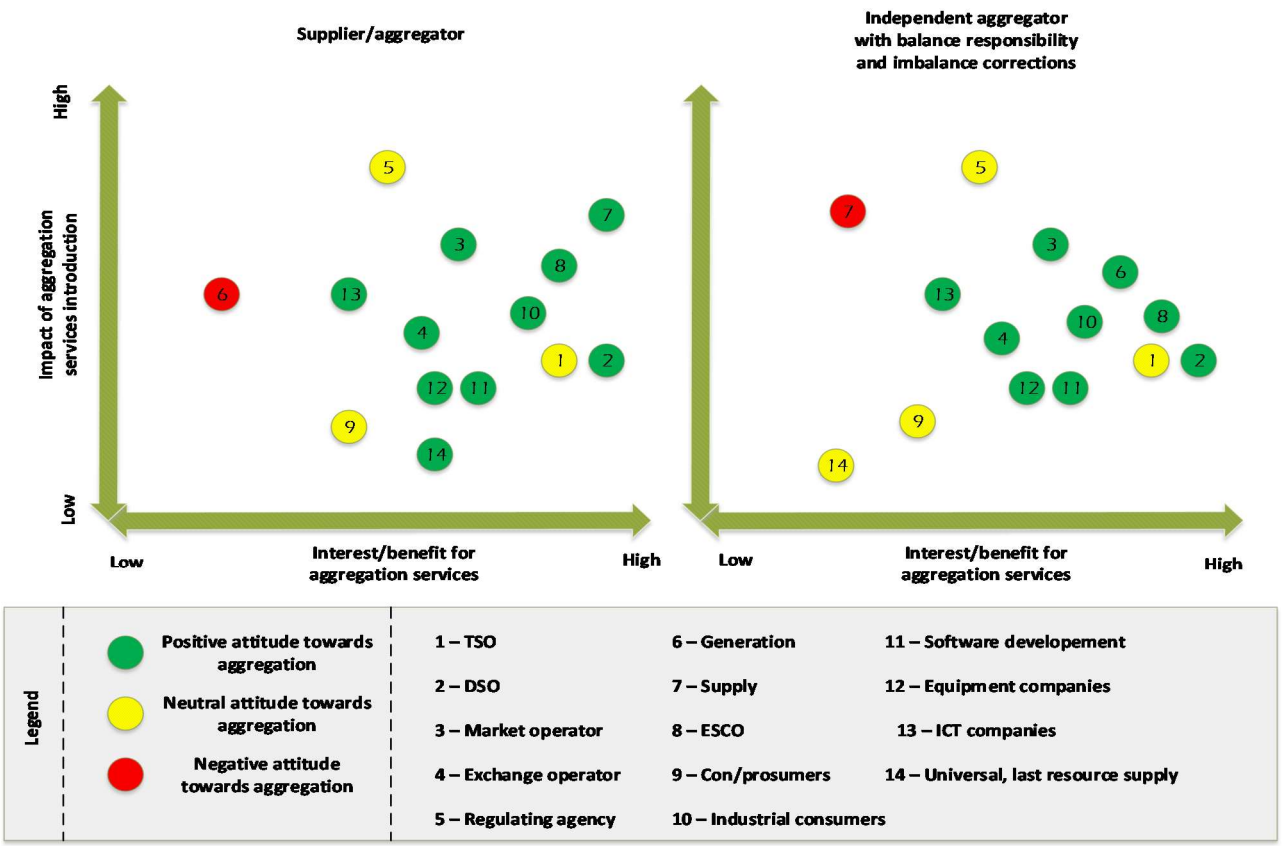

Figure 3 Impact of implementation of aggregation services on traditional power system participants

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 for which provision they are not remunerated in Croatia) and they can sell their capacity on more profitable markets. Generation companies can also suffer from revenue 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 resort 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 accordingly by their thorough examination. The induced cost should be minimal, whereas the total social welfare should be optimal.

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