By Baptiste GARCIA-RUNDSTADLER

Energy Economist within the Economic Advisory team of Deloitte France

Reaching the optimum: from monopoly to aggregators

The power sector industry used to be composed of vertically integrated monopolies. Since the early 2000's, EU has witnessed a dynamic of liberalization of the sector, leading to an increase in the number of players and the rise of market places to link them[30]. More recently, the IT revolution and the growing interest in renewables are leading to even more decentralization of generation (with distributed generation such as wind turbines and PV panels), pro-active consumption[31] and storage means. In a few decades, the sector has switched from large production means all owned by a single operator to multiple small means owned by various market players. **This trend towards decentralization has also led to the birth of a new kind of player in the power industry: the aggregator.**

The aggregator acts as an intermediary between multiple players[32] and a market place. Its added value can be twofold: **it enables small players to reach the required size to be able to participate in some markets**[33] ; and **it enables the global optimization of all aggregated assets**. In a recently liberalized industry going through disruptive changes related to the energy transition and IT revolution, how do aggregators emerge and find their place?

Aggregators gather multiple players to enable them to reach the required size to enter some markets and perform a global optimization of their asset.

1. Demand response

Demand response is the action of enhancing the flexibility that can be provided by consumption means, by reducing the level of consumption when receiving an external signal. This can be a price signal or an explicit demand from the TSO for example. Demand response can reduce peak consumption and avoid using expensive generation capacities or reinforcing the grid. The flexibility at stake comes from big industrial sites, tertiary buildings or even individual residential houses. Some large industrial sites already have demand response capacity on their own and do not necessarily need to rely on aggregators to value the flexibility of their heavy-consuming processes. Still, a vast majority of demand response is performed through aggregation[34]. Such aggregator included in 2016 Actily, EDF, Engie, Energy Pool, Smart Grid Energy, Valoris Energy and Voltalis[35]. **The aggregator can mutualize costs to enter the market of demand response**[36] **and help achieve the minimum required technical thresholds for those markets.** Through the aggregator, a large panel of sites can combine their flexibility resources, leading to a greater efficiency than individual optimization of each site[37]. **The aggregator optimally dispatches those resources in order to smooth peak consumption, hence reducing production costs and CO2 emissions**[38]. For example, aggregators will dispatch consumption (heavy processes, electrical heating) during off peak period, avoiding high prices during peaks (e.g around 7PM in France during winter). Note that historically demand response only applied to large industrial sites given the fixed costs of the required control-command infrastructure to monitor processes and perform demand response. Now that those IT infrastructure costs have shrank with the digital revolution, aggregators can access new markets such as tertiary buildings and even individual houses[39].

30 Generation, transmission, distribution and supply used to be different activities performed by the same company. Today, generation and supply are liberalized and new markets have emerged, the biggest one in terms of volume being the day-ahead market where producers bid their production one day in advance. However, transmission and distribution are natural monopolies, hence regulated by authorities. Unbundling requirements ensure the separation between liberalized and regulated activities.

31 Demand response is one of the main decentralized pro-active consumption features enabled by IT.

32 E.g., small owners of PV power plants, industrial sites that can control their load, domestic consumers, …

33 E.g., an owner of a small wind farm with only a few turbines who wants to get capacity certificates to participate in the capacity market.

34 For example in France, the aggregators represent two thirds of the total demand response capacity (source: RTE, Bilan Prévisionnel 2016).

35 Source : RTE (link)

36 Such costs include, for example, financing the required infrastructure to bid in markets.

37 Mathematically speaking, a global optimization is more efficient than a sum of local optimization. For example, each residential consumer on its own has limited capacity to do demand response. Indeed, this would mean cutting its heating for several hours, leading to a significant decrease in the house's temperature. By aggregating several houses, the load reduction can be dispatched among different consumers, hence reducing the impact on each house (each consumer would see its consumption decreased for a shorter time).

38 Peak production mean, such as combustion turbines, have usually very high emission rate compared to baseload production.

39 The latter are not big enough to participate in demand response on their own, both from a regulatory and economic point of view.

Several solutions have been implemented to enable large-scale demand response participation in power markets. France is a good example: the country faces one of the biggest peak consumption in Europe and has been proactive in developing the regulatory infrastructure around demand response. Market players for demand response include aggregators and large consumption sites that participate on their own. Given the preponderance of aggregators, we will use in the rest of the article the term aggregators to refer to demand response players.

Aggregators in demand response optimally dispatches consumption from multiple sites to provide flexibility to the grid as well as reach minimum required side for some markets and reduce fixed costs. In France, market design had to be adapted to enable large scale participation of demand response.

- The NEBEF mechanism (Block Exchange Notification for Demand Response)[40], part of the *Loi Brottes (2013)*, enables a third-party player (such as an aggregator) to perform load reduction of a consumption site without having to obtain any permission from its supplier. In this context and from the network point of view, reducing load is exactly like producing the same amount of energy. This energy not consumed, for example by an industrial site, is sold on the market by the aggregator. The NEBEF mechanism specifies the financial flows between the industrial site, its supplier, the aggregator and markets[41]. It enables the aggregator to get a revenue in €/MWh of load reduction. It is important to highlight that the way to measure this reduction of load is crucial and very complex, as we measure something that has not been consumed.
- Besides NEBEF, aggregators are allowed to participate in the capacity market where they can make a revenue in €/MW of their maximum capacity. The authorisation to actually aggregate capacity to reach the minimum bidding capacity is key in the process.
- In addition, the French TSO RTE created a specific tender for tertiary reserve for demand response players (aggregators representing the majority of them), with a remuneration in €/MW as well. It should be highlighted that in France this dedicated market is by far the main source of profit for aggregators[42].

2. Renewable generation

In France, demand response has been the most suited playground for aggregators to appear; but in Germany, the business first grew for renewable production means.

The past decade has seen the rise of renewable generation and national support schemes to ensure the rapid development of these technologies, the most widespread being feed-in-tariff (FIT). Feed-in-tariffs guarantee to renewable producers a price per MWh, no matter how much and when they produce, thus enabling them to bypass markets. But recently (since 2012 in Germany), FIT tend to be replaced by feed-in-premium. Renewables then have to bid on the market and are paid ex-post the difference between the reference tariff (subsidized) and the market price. The major difference is that having to bid in energy markets, **renewables need to forecast their generation level**, a challenge for wind and solar capacities. Thus, if the sold generation differs from the actual level, an **imbalance penalty** will apply to the renewable power producer, reflecting the cost for the system to cope with this imbalance. Aggregation then makes sense for two reasons. First, **there are a number of fixed costs associated with bidding in the market, which aggregators can mutualize between multiple renewable power producers.** Second, forecast errors decrease as the number of wind turbines (or PV panels) increases, especially when generation means are not located in the same region. This phenomenon, often referred-to as the **diversity effect**, is due to the fact that wind speed forecast errors (or sun irradiation) for two different regions are likely to partly compensate each other as forecasts include different wind regime. An error on one wind regime will see its impact lowered thanks to other regimes' forecasts being more accurate. Therefore, **aggregating the bids of several sites can lower the uncertainty and then the amount of imbalance penalties to be paid**. In Germany, there are more than 70 aggregators for renewables with a total aggregated capacity of 40GW[43],[44]. Some companies like Centrale Next are now entering less mature markets such as France, where the obligation for renewables to bid in markets is much more recent (2016).

Aggregators create value for renewables by being responsible for bidding in the market and by reducing penalty costs due to forecast errors thanks to the diversity effect.

Aggregators take care of the forecasting and bidding of the renewable generation while paying to producers the amount of energy they actually produced at a price defined in advance. Aggregators can thus be simple interfaces linking renewable capacities, but they can also be actual producers owning a thermal power plant, which are controllable unlike PV and wind power, who propose additional services. For instance, Uniper (previously E.on) proposes these aggregation services to reduce imbalance penalties and in addition compensates uncertainties due to remaining forecast errors with the flexibility provided by its thermal units. This implicitly means that **for Uniper the energy from its thermal plants has less value than their flexibility, and that this flexibility has greater value off the market (to avoid imbalance penalty for renewables) than within**[45].

Some power producers now prefer to sell their flexibility to renewables to accommodate forecast errors rather than selling it to the grid directly.

40 Link RTE

41 The demand response player pays to the supplier the amount of reduced load at the tariff previously set between the supplier and the consumption site. In exchange, it can sell that electricity in markets, at a higher price, and gets remunerated on the price differences.

42 Source : Energy Pool, leader of Demand Response in France.

43 Total intermittent capacity (wind and PV) in Germany is 90GW. Big players already do their own "aggregation" internally as an optimization.

44 Source : http://www.energie.sia-partners.com/20161117/complement-de-remuneration-pour-les-energies-renouvelables-le-role-renforce-des-agregateurs

45 Such as balancing market for example.

3. EV charging

Energy transition also means a huge increase of electric vehicles in a near future. Being decentralized assets very suitable with IT infrastructure and containing storage capacity, electric vehicles can be of high interest for aggregators.

Electric vehicles (EVs) are often considered as a corner stone of the 3D revolution of the energy sector: digitalization, decarbonisation and decentralization. Certainly, a fleet of EVs can be a game changer in the electricity sector, and turning them from a burden for the grid to a high benefit asset relies on the role of aggregators. Indeed, if not properly managed, a charge of nearly all EVs simultaneously (when people get back home around 7PM, i.e during peak time) can lead to a massive rise in the peak demand, thus requiring very expensive and polluting peak generation capacities and reinforcing the grid. A recent study from the European Climate Foundation shows that **in a 2050 scenario with 25.4 million EVs in Germany, smart charging could turn a €1.35b extra cost into a €110m net benefits**[46]. Not only can **aggregators shave the peak consumption by dispatching the charge of all EVs appropriately**, in particular during the night (by controlling directly the charge of all vehicles for example, or by sending financial incentives to end-users), they can also **use their batteries to provide services to the grid** such as frequency regulation, thus reducing costs for the network and for car users.

Still, a number of barriers are to be overcome for aggregators to successfully optimize charging of EVs. Among them and as in demand response, **interoperability** is of the essence. Interoperability means anyone with given permission can interface with the system. Hence, all charging stations should fit all EVs, for charging purposes as well as for information exchanges. **Standardization** is then required[47]. Another major barrier is at the social level and is much more complex to address: **acceptance** from people not to control their charging time. Indeed, minds will have to switch from an almost instant charging whenever the user decides it, to a simple guarantee of having the car being charged for the next morning, all control of when the car is actually charging being left to an algorithm.

4. Batteries

Aggregators look at using the batteries of EVs when plugged, but batteries on their own can also be of high interest.
The use of batteries is comparable to EVs'. Originally designed to store energy, **charging when energy is cheap and discharging when prices are high is not a reliable business model** given current costs for batteries and experienced spread in energy prices. However, **their ability to deliver very fast response finds value in frequency regulation services, and can be complementary with other means**. For instance, the international innovative flexibility services company REstore uses battery combined with heavy industrial processes for its demand response offer, making it more reactive and enhancing its value. When the signal asking to reduce load is received, the battery first discharges during the time needed for the industrial process to actually reduce its load. The value of the aggregator lies in the ability to combine efficiently different means (storage, industrial processes) to enhance reactivity.

Aggregators optimally dispatching the charge of EVs and using their batteries to provide services to the grid is key to turn EVs from an economic burden to a valuable asset for the grid.

5. Conclusion

Compensating renewable intermittency with flexibility is exactly what is done by the Transmission System Operator (TSO) to ensure the balance between supply and demand. **Had the power system not been liberalized, this optimization would have been done by a vertically integrated monopoly controlling all assets of the whole value chain (production, transport, distribution and retail), with a view to minimizing total cost and hence maximizing social welfare. Nowadays, producers, aggregators and traders**[48] **all seek to maximize their profit separately**. From a mathematical point a view, we have switched from a global optimization to a sum of local optimization for each player. Economics theories suggest that efficient markets can enable to coordinate players' decisions to reach a global optimum as the previous monopoly could have done. Unfortunately, in complex and technical problems the sum of multiples optimization problems very rarely matches results of a global optimization... Aggregators partly fill this gap.

46 Source: European Climate Foundation, link to publication.
47 Source : Ghazale Haddadian et al., Accelerating the Global Adoption of Electric Vehicles: Barriers and Drivers, In The Electricity Journal
48 Traders can buy and sell in market places without producing any energy at all.