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Abstract

The importance of independent aggregators has been acknowledged in the recently adopted EU Clean Energy Package (CEP). The CEP obliges all Member States to develop a regulatory framework to allow these players to enter the market, but it leaves many of the details of implementation to the national level. In this paper, we take stock of current practices in regulating the contractual relationship between the supplier and the independent aggregator. The actions of an independent aggregator can cause an imbalance in a supplier's portfolio, and suppliers have also asked for a compensation payment for forgone revenues. We find that the first issue has been handled with a perimeter correction in most countries, while the second issue is more controversial. The need for a compensation payment has been challenged and many different compensation models are being tested. We distinguish between the regulated, the corrected, and the contracted model. We conclude that more guidance is needed at EU-level for convergence on a more harmonized approach.

Keywords

Demand Response, Independent Aggregation, Retail Markets, Innovation, Regulation.

1. Introduction*

Demand-side response (DR) is a change in electricity consumption in reaction to a price signal. DR has been acknowledged for many years as an important resource that can compete with the supply-side solutions in electricity markets if regulatory barriers are removed. Some of the benefits of DR highlighted in the literature are lower investment needs in power generation, the reduction of market power in wholesale markets, avoidance of overinvestment in networks, and lower needs for reserves (Burger et al., 2017; O’Connell et al., 2014; Paterakis et al., 2015; Strbac, 2008). As DR can respond quickly to changes in power system conditions, its value is expected to increase further in the transition towards a greener and more intermittent generation mix. DR also allows consumers to better understand electricity usage and can, therefore, lead to improvements in energy efficiency and emissions reductions (Dahlke and Prorok, 2019; Wohlfarth et al., 2020).

The European Commission (2016) estimated that the DR potential was 100 GW in 2016, while around 20 GW was considered active: DR potential would, the Commission judged, increase further to 160 GW by 2030. Most countries tapped into the DR potential of industrial users, leaving the DR potential of smaller commercial and household consumers largely untapped. This is unfortunate because Gils (2014) finds that around half of the potential for load curtailment can be found among household consumers. The DR potential of smaller electricity users is also expected to increase with the uptake of flexible technologies such as electric vehicles and heat pumps.

DR is a broad concept. ACER and CEER (2016) and SEDC (2015) divide DR into an implicit and explicit response. If a consumer reacts to the price signals included in their energy bill, the response is referred to as implicit. Network tariffs and retail prices will become increasingly dynamic with the introduction of smart meters and are expected to have an impact on consumers’ behaviour. To the extent that consumers do not respond enough to these price signals, it can also be opportune to contract DR explicitly. Explicit DR can be activated by an independent aggregator via a separate contract that stipulates when the response can be activated, and at what price. Explicit DR can also be integrated in a supply contract. New innovative suppliers offer a discount on the price that consumers pay to source energy. In return consumers then agree that the supplier uses their smart devices to respond to electricity market signals.

Independent aggregators have been defined in the Clean Energy Package (CEP) in Art. 2 (19) of the Directive (EU) 2019/944, as « *a market participant engaged in aggregation who is not affiliated to the customer’s supplier* ». Aggregation is defined as « *a function performed by a natural or legal person who combines multiple customer loads or generated electricity for sale, purchase or auction in any electricity market* ». Suppliers can provide aggregator services, but they have been relatively slow in taking up this role, which is why the concept of independent aggregators emerged (Bray and Woodman, 2019; Burger et al., 2017; Good et al., 2017; He et al., 2013). Traditional suppliers are inherently reluctant to offer DR programmes as these services affect their core business: selling volumes of energy. For example, Poplavskaya and De Vries (2020) observe that several independent aggregators come from the telecommunication or digital sector because the business model is different from that of traditional suppliers.

According to the CEP, Member States shall enable DR through independent aggregation. Directive (EU) 2019/944 in Art. 17 includes the principles that the national regulatory frameworks must respect.

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Regulation (EU) 2019/943 states in Art. 59(1.e) that a new network code can be developed in the area of DR, including rules on aggregation, energy storage, and demand curtailment rules. Network codes are typically used to harmonize the regulatory frameworks at the national level. Küpper et al. (2020) state that without harmonized frameworks, aggregators will face higher costs for participating in electricity markets and that cross-border competition will be distorted. How this will be implemented is one of the main open issues in the evolution of electricity markets in Europe (Meeus, 2020).

In this paper, we focus on the contractual relationship between independent aggregators and suppliers. The actions by an independent aggregator can cause an imbalance in the portfolio of a supplier, and suppliers have also asked for a compensation for forgone revenues. For each of these two issues – portfolio imbalances and foregone revenues – we review the literature, and we also take stock of the most recent developments in Europe following the implementation of the relevant CEP provisions.

The paper is organised as follows. Section 2 provides a schematic representation of the contractual relationship between a supplier and an independent aggregator. This allows us to introduce the two main issues that arise: i.e., the imbalance issue, and the foregone revenues issue. Section 3 then discusses how EU Member States deal with the supplier imbalance caused by the independent aggregator and Section 4 discusses the foregone revenues issue. Section 5 describes three open implementation issues inherent to the split responsibility of the supplier and the independent aggregator. We conclude with policy recommendations.

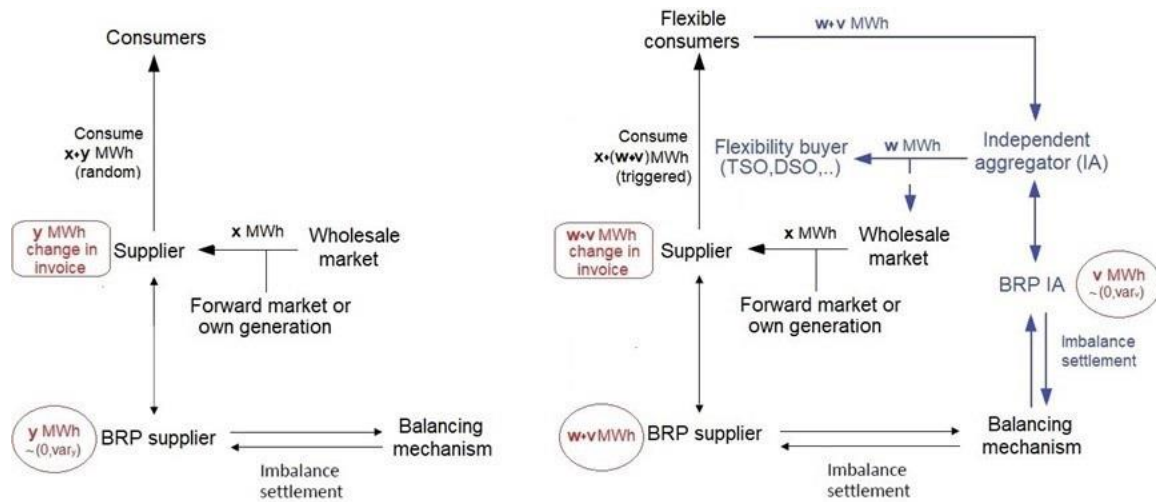
2. Schematic representation

Independent aggregators offer DR bids to markets. These bids entail a certain reduction (or increase) in the consumption of the contracted consumers compared to a baseline. Suppliers purchase a certain amount of energy in advance to cover the consumers' expected load and they are responsible for having a balanced position in real time. In this section, we illustrate how the actions of independent aggregators affect suppliers and the Balancing Responsible Party (BRP) designated by the supplier. The BRP can be the supplier itself or a third party. For simplicity's sake, we assume that all consumers contracted by the independent aggregator are supplied by the same supplier.¹

The left part of Figure 1 illustrates a situation without DR. Imagine a supplier purchasing x MWh for its consumers for a certain imbalance settlement period (typically fifteen minutes or one hour). The supplier purchases this volume of electricity either through long-term contracts, or in the day-ahead and intraday market. In case of a vertically integrated supplier (with generation), the supplier can also generate the electricity. Due to forecast errors, the consumers will finally consume $x+y$ MWh. Depending on whether y MWh is positive/negative, the supplier will charge y MWh more/less than anticipated *via* the electricity bill to the consumers. The supplier's BRP will be imbalanced by y MWh. Typically, the y MWh in this example is drawn from a distribution with a mean around zero. The better a supplier can forecast the aggregated consumption of its consumers, the smaller the variance of the distribution of random deviations (var_y) will be. The BRP will be rewarded or will have to pay the TSO through the imbalance settlement: this will depend on many factors among which the direction of the BRP's portfolio imbalance and the direction of the system imbalance during the given imbalance settlement period.

¹ When consumers belong to different suppliers, the actions of the consumers triggered by the independent aggregator shall be settled per respective supplier (and the respective BRP). This procedure can create additional implementation issues as discussed in Section 5.

Figure 1: Left- situation without DR. Right- situation with DR via an Independent Aggregator (IA) without any correction or compensation.



The right part of Figure 1 shows a situation with DR. Imagine that during this imbalance settlement period, a w MWh DR bid from the independent aggregator is cleared by a market. This bid could be cleared in the day-ahead, intraday, balancing, or in a flexibility market. To fulfil this bid, the independent aggregator needs to trigger an adjustment in consumption from its contracted flexible consumers compared to their baseline. We consider x MWh to be the baseline. In this example, the consumers adjust their consumption with $w+v$ MWh after being triggered by the independent aggregator. v MWh is the difference between the estimated change in the consumption of the flexible consumers and the flexible consumers' actual adjustment in energy consumption relative to the baseline. As stated in Directive (EU) 2019/944 Art. 17(3.d), the independent aggregator is responsible for its imbalances, thus the independent aggregator's BRP will be imbalanced with v MWh. v MWh is typically drawn from a distribution with a mean around zero. The more precise the independent aggregator's control over the flexible consumers' consumption, the smaller the variance of that distribution (var_v) will be. Importantly, due to the actions of the independent aggregator, both the BRP of the supplier and the supplier itself are affected.

First, the imbalance of the supplier's BRP will be $w+v$ MWh, while the absolute value of $w+v$ is expected to be larger compared to $|y|$ (left part of Figure 1) and not necessarily random.² Like the BRP of the independent aggregator, the BRP of the supplier will be subject to the imbalance settlement. Depending on the whole system imbalance, the independent aggregator's intervention can result in a loss or a profit for the supplier's BRP. Art. 49 of the Electricity Balancing Guideline (EB GL, Regulation (EU) 2017/2195) requires that «Each TSO shall calculate an imbalance adjustment to be applied to the concerned balance responsible parties for each activated balancing energy bid». However, whether the same principle should be applied when activated balancing energy bids have been offered by a third-party Balancing Service Provider (BSP) is an open issue. Also, the DR bid might be offered not in the balancing energy market, but in, say, a flexibility market for local congestion running near real-time (see e.g., Schittekatte and Meeus, 2020), for which no similar provisions exist.

² Please note that, as such, during time steps of interventions by the independent aggregator the risk of the random deviation of flexible consumers around their forecasted demand (according to var_v) is internalised in the random deviation between the consumption adjustment requested by an independent aggregator and the realised consumption adjustment (according to var_v).

Second, as described by Chao (2011), when contracting with a supplier, consumers are provided with a volumetric call option giving them the right to consume any amount of electricity up to the connection capacity, often, at a predetermined price. In this case, the independent aggregator triggers the consumer to exercise the option at x MWh, while the consumption level for which the consumer is billed for is $x+(w+v)$ MWh. In case of a load reduction ($w+v$ being a negative number), this implies that the independent aggregator sells energy (on behalf of the consumer) that has not been bought by the consumer *via* a preceding transaction. It also means that the supplier has sourced more energy than it can bill the consumer for. As such, the independent aggregator's actions are expected to result in a monetary loss for the supplier. DR may be activated to increase load, resulting in the opposite situation. However, this is currently an exception. Most of the time consumers are asked to reduce their load (see also e.g. Alba et al., 2021).

3. The imbalance issue

In this section, we first discuss the need to correct the supplier's BRP. Afterwards, we describe in more detail how this kind of correction is done.

3.1 The need for a correction of the supplier's BRP

Baker (2017) and Voltalis (2020) argue against a correction of the supplier's BRP. In their view, the imbalances created by the actions of the independent aggregator will financially benefit the supplier's BRP. This is the case when the accepted DR bid is expected to help balance the system. The supplier's BRP will have an imbalance in the opposite direction to that of the system imbalance which, depending on the exact implementation of the imbalance settlement mechanism, will result in an income.³ This kind of a double payment is undesirable from a system point of view. It is costly and can lead to strategic behaviour. Note also that the actions of the independent aggregator will not always result in a "system-favourable" imbalance for the portfolio of the supplier's BRP. The aggregator can also decide to sell its flexibility on the wholesale market or other flexibility markets. In this case, there is no clear relationship between the direction of the imbalance of the supplier's BRP created through the actions of the independent aggregator and the direction of the system imbalance.

3.2 The perimeter correction

A straightforward way to correct the imbalance of the supplier's BRP due to the actions of the independent aggregator is through a so-called 'perimeter correction'. With a perimeter correction, the imbalance of the supplier's BRP is corrected with the metered volume of energy activated by an independent aggregator's action. This corresponds to an extension of the imbalance adjustment to third party BSPs, including for bids in markets other than the balancing energy market. The correction is done ex-post, in most cases by the TSO.⁴ As such, the supplier's BRP is not held responsible for actions it cannot act upon.

As in the schematic representation in Section 2, the perimeter of the supplier's BRP is corrected by $w+v$ MWh, i.e. the energy activated by the independent aggregator's action. This holds in case the baseline for the independent aggregator's actions is x MWh. Three implementation difficulties with the perimeter correction are discussed in Section 5. An alternative to the perimeter correction could be ex-

³ For more information on the imbalance settlement mechanism as regulated in the EB GL, please see Schittekatte et al. (2020).

⁴ Alternatively, the correction can also be done by adjusting the metered profiles of the consumers for the DR activation as in the corrected model, which is described in more detail in Section 4.

post financial compensation. However, as also described by DNV GL (2017), this kind of solution would bring more complexity in terms of the organisation of payments and the calculation of settlements.

Today, in European countries the vast majority of products sold by independent aggregators are subject to a perimeter correction. This is for example the case: in Belgium (CREG, 2018); France (RTE, 2019); Great Britain (within the TERRE project, DNV GL (2019)); Switzerland (Minniti et al., 2018; Swissgrid, 2019); and it is planned for Germany (RAUE, 2017; Wimmer and Pause, 2019) and for Slovenia (Borzen, 2019). An exception to this rule is proposed when an independent aggregator sells products with capacity reservation payments, which entail a low amount of activated energy. An example is the provision of Frequency Containment Reserve (FCR). For such products, the implementation costs of any correction mechanism is deemed to be higher than the value of mitigating the limited risks for the supplier's BRPs. This reasoning was followed in Belgium and has also been proposed for Finland (Elia, 2019; Pöyry, 2018).

4. The foregone revenues issue

In this section, we first summarize the arguments for and against compensation payments. We go on to describe how compensation payments are made in practice. Lastly, we discuss the different compensation models that were introduced within the EU.

4.1 Arguments for and against a compensation payment

Hogan (2010a, 2010b) argues that without a compensation payment, explicit DR is remunerated more than implicit DR, which leads to market distortions.⁵ It creates incentives to move generation behind the meter in organized markets and the implicit subsidy for this explicit DR would be paid by consumers that are less able to participate in DR programs. Along the same lines, DNV GL (2017) and NordREG (2020) fear that if the sourcing costs are not internalized by independent aggregators, they could offer DR bids at more competitive prices than suppliers engaged in aggregation (integrated supplier-aggregator model). This would distort competition and could lead to excessive DR (Crampes and Léautier, 2015a; Pöyry, 2018). Note that in the US context, the debate focussed on correct DR pricing (Bushnell et al., 2009; Chao, 2011; Chao and Depillis, 2013; Hogan, 2010a, 2010b). In Europe, the debate instead is focussed on the competition between independent aggregators and suppliers (DNV GL, 2017; Eurelectric, 2015; NordREG, 2020). The different emphasis laid in the EU and the US might be explained by the fact that electricity supply is a competitive activity in the EU Member States, while this is not the case in many states in the US. When electricity supply is a regulated monopoly, as it is in many US states, there can be no adverse impact on (non-existing) supplier competition due to independent aggregators. Instead, in that context, not requesting a compensation payment from the independent aggregator after a DR activation, i.e. paying the full wholesale electricity price, implies the socialisation of the compensation payments.⁶

An argument against a compensation payment is that an implicit subsidy for independent aggregators can increase electricity supply competition (where supply is a competitive activity). The inherent conflict between the supplier business and the DR business would be mitigated and the sudden "need

⁵ Hogan (2010a) distinguishes between explicit DR based on baseline estimates, which he calls imputed DR, and explicit DR by consumers purchasing a fixed quantity of electricity in an organised wholesale market but consuming less than the purchased amount and selling back the difference. We refer to the former type of explicit DR. For the latter type, which is currently only feasible for very large consumers, there are obviously no such issues as the consumer is responsible for its own supply.

⁶ The different regulatory model in several US States also has an impact on the actors providing aggregation services. For example, in California there are both DR programs managed by the regulated utility (supply and distribution company) and (third-party) aggregators (California Public Utility Commission, 2021). In Europe, providing DR *via* aggregation is always a competitive activity.

to innovate’’ for suppliers could ultimately lead to cost savings and enhanced energy services for final consumers. For example, Su and Kirschen (2009) observe that increased DR participation leads to substantial savings in system operating costs: these are transferred to the demand-side. According to Baker (2016, 2017), independent aggregators will help to reduce wholesale prices, and suppliers may be able to keep the benefits of decreased wholesale prices because of imperfections in retail competition. In that regard, ACER and CEER (2020) observe a strong correlation between retail and wholesale energy prices in the EU when wholesale energy prices increase. However, retail prices do not always follow a reduction in wholesale energy prices. This phenomenon is called “downward sticky prices”. This reasoning has led some stakeholders, such as BEUC (2018), to argue that if compensation payments were to be established, they should only be introduced when net losses for the supplier are identified.⁷ This argument is acknowledged by Directive (EU) 2019/944. There it is stated in Art. 17(4) that «*the method for calculating compensation may take account of the benefits brought about by the independent aggregators to other market participants and, where it does so, the aggregators or participating customers may be required to contribute to such compensation but only where and to the extent that the benefits to all suppliers, customers and their balance responsible parties do not exceed the direct costs incurred*».

Baker (2016), Pöyry (2018) and Voltalis (2020) have also argued that (part of) the compensation payment for the supplier should be socialised.⁸ They invoke Art. 17(4) of Directive (EU) 2019/944 which states that a supplier compensation can be introduced but that this compensation shall «*not create a barrier to market entry for market participants engaged in aggregation or a barrier to flexibility*». An example of the implementation of the socialisation of part of the supplier compensation is France. In France, for the imbalance settlement periods where a consumer reduces its consumption by more than 40% compared to its baseline, the TSO socialises up to 50% of the compensation costs (Code de l’énergie Art. R.271-10-15). More discussion can be found in USEF (2017).

4.2 Compensation payments in practice

In what follows, we first refer to the countries that have chosen an non-compensation model, and then discuss the three alternative models that have been implemented in Europe: the regulated model; the corrected model; and the contracted model. Table 1 summarizes these models.

Table 1: Summary of the three models to compensate the supplier

	<i>Regulated model</i>	<i>Corrected model</i>	<i>Contracted model</i>
<i>What is the level of the compensation?</i>	Determined by a methodology approved by the regulator	The retail price	Bilateral deal between independent aggregator and supplier
<i>Who pays the compensation?</i>	Typically, the independent aggregator	Typically, the consumer <i>via</i> the electricity bill, possibly passed through to the independent aggregator	Typically, the independent aggregator
<i>Examples of countries</i>	Switzerland and Slovenia, option in France and Belgium	Large consumers in France, planned in Germany	Option in Belgium and France

⁷ Whether there is a no net loss, i.e. a potential difference between wholesale and retail prices that is large enough to compensate for the decrease in the volume of invoiced energy, will depend on the ‘stickiness of the retail prices’ and the shapes of the supply and demand curves.

⁸ The outcome would be similar to the case when supply is a regulated activity and when no compensation is asked for.

First, there is the model without compensation. As described in Ma and Venkatesh (2020) and The Brattle Group (2015), in the US the Federal Energy Regulatory Commission (FERC) issued Order 745 “Demand Response Compensation in Organized Wholesale Energy Markets” in March 2011. It did so to enable greater DR participation in electricity markets. FERC ordered that DR shall not pay a compensation payment and be paid at the full wholesale market prices when a net benefit test is passed. To pass the net benefit test, the benefits to consumers from dispatching DR shall exceed the payments to DR providers. The FERC does not prescribe the implementation method for the net benefit test. The different Independent System Operators (ISOs) have to submit their methodologies for the net benefit test to FERC for approval. In that regard, Chao and Depillis (2013) demonstrate that paying demand reductions the full wholesale price (i.e. without having to pay a compensation) can bring a net benefit. But this is only the case under certain assumptions and under the condition that the demand reductions are activated solely at moments when the wholesale price is at least twice the retail rate. The Order 745 was controversial and disputed as described by Chen and Kleit (2016) and Panfil (2015). However it was upheld by the Supreme Court of the United States (2016). As far as the authors are aware, no compensation mechanism is in place in Great Britain (DNV GL, 2019).

Second, there is the regulated model. By using price indices such as the day-ahead price or forward prices in the compensation formula, this model aims at covering the sourcing costs or the foregone revenues of the supplier: the sourcing costs plus a retail margin. Depending on the country, the calculated price can change hourly, as in Belgium, or is more static as in France. Another important difference between the Belgian and French implementation is that in France, the French TSO RTE has established a centralised platform to facilitate the financial flows and dispute settlements for the regulated model. This kind of implementation is sometimes also referred to as the central (regulated) settlement model (USEF, 2017). Similarly, in Switzerland, the aggregator is obliged to compensate the supplier for the difference in consumed energy with a payment that is determined by TSO based on the day-ahead spot price of the Swiss Electricity Index (Chacko et al., 2018; SEDC, 2017). In Belgium, the regulated compensation is settled bilaterally without any intermediary. Slovenia is also planning to implement the regulated model. The final form of the national legislation is expected to be published in the summer of 2021 (AGEN, 2020; PIS, 2020).

Third, there is the corrected model. This model implies that the consumers’ load curves are corrected for each activated DR bid. Supplier invoicing is then based on the corrected profiles. As such suppliers receive the revenues they would have received, and the independent aggregator does not have to compensate the supplier. Instead, the consumer is implicitly paying for the compensation by paying the retail bill for a corrected consumer profile. The corrected model has been used in France for more than five years for large consumers (CRE, 2019; Pentilateral Energy Forum, 2017) and is planned for Germany (RAUE, 2017; Wimmer and Pause, 2019).

Fourth, there is the contracted model. This model implies that the independent aggregator needs to agree with the supplier on a compensation payment. Unless this model is combined with another model, it seems to be in conflict with the Directive (EU) 2019/944 Art. 13 (2) stating that «*Member States shall ensure that, where a final customer wishes to conclude an aggregation contract, the final customer is entitled to do so without the consent of the final customer’s electricity undertakings*». In Belgium, the contracted model is the encouraged model, but if the different parties do not manage to come to an agreement the regulated model can be used (CREG, 2018). In France, consumers connected to lower voltage levels follow the regulated model by default. But they can negotiate the level of the compensation, as in the contracted model, if they want to.

4.3 Discussion of the three European compensation models

Important arguments in favour of the regulated compensation model are that this model can, it is claimed, neutralise the potential abuse of power by the supplier and is easy to duplicate for many consumers once it is in place. There is a fear that the contracted compensation model, wherein independent aggregators

need to reach an agreement with the consumers' existing supplier, could lead to significant bargaining power for large incumbent suppliers and high transaction costs.⁹ In principle, for each consumer-independent aggregator relationship another compensation scheme can be set up. This is less of an issue when an independent aggregator engages with a big industrial consumer, but it becomes very burdensome when engaging with smaller consumers such as households. Also there is an abuse of power risk on the part of suppliers in the corrected compensation model. In this case, the abuse would be towards the consumer rather than the independent aggregator. Suppliers can discriminate flexible consumers in the corrected model when in the electricity bill the total electricity consumed is separated from the total electricity sold as DR. This practice is called double billing. To prevent suppliers identifying which consumers are engaged in DR, single billing can be used. With single billing, suppliers only know the total amount of electricity that is being purchased per consumer. However, significant changes to the legislation governing the invoicing procedure and governing electricity taxation might be needed to allow for single billing. This is remarked upon by Alba et al. (2021), CREG (2016) and Elering et al. (2017). CREG (2016) adds that in the corrected model consumers are brokers between the independent aggregator and the supplier, while the aggregator-supplier relationship should not be its worry.¹⁰

On the downside, as argued by NordREG (2016) and Elering et al. (2017), the regulated model necessitates careful regulatory decisions of which the effectiveness are hard to guarantee and which can be slow to review. The energy sourcing strategy of each supplier is unique, which is not easy to capture in a compensation formula that is designed by the regulator. Regarding the determination of the exact compensation payments, the contracted model is flexible and the corrected model is also straightforward as the suppliers are compensated at the retail price agreed upon with their consumers. In short, the contracted and the corrected model reduce the burden on the regulator in terms of defining the regulatory framework ex-ante. But these two models might require more ex-post regulatory monitoring.

5. Open implementation issues

Some technical difficulties remain in the implementation of the perimeter correction and in any compensation model. These implementation issues are inherent in the split responsibility of the supplier and the independent aggregator. We describe three issues that are recurrent in the relevant literature: the aggregation of consumers belonging to different suppliers; the rebound effect; and the accuracy of telemetry and baseline definitions.

First, NordREG (2016) raises concerns about the technical feasibility of properly allocating imbalances and compensations to suppliers (and the respective BRPs) when one independent aggregator brings together many consumers who have contracted with different suppliers. Only the total activated volume by an independent aggregator is visible for the market operator or the TSO, not the volumes belonging to each consumer group. It could be argued that the independent aggregator can provide this information separately to the TSO on its own initiative. The question remains, however, whether metering data provided by the independent aggregator's BRP could be used in an official financial settlement between two potentially competing market actors. Mandating independent aggregators to form bids from consumers with the same supplier could be an option. But this would limit the business model of independent aggregators. A potential solution to this issue might be to have a Flexibility Resource Register (FRR) in place governed by a neutral party. The FRR gathers information on the

⁹ Under perfect retail competition, the risk for such behaviour would be lower as consumers would be able to switch to suppliers who are willing to sign a contract with independent aggregators, but concerns would remain (Elering et al., 2017; Eurelectric, 2015).

¹⁰ An alternative is having consumers directly passing on the compensation costs to the independent aggregator. However, in that case the independent aggregator would have access to sensitive information, namely the retail price a consumer pays. In that case the aggregator is also engaged in supply activities (but not for that consumer), the aggregator would be able to make a better offer than the existing supplier, distorting competition.

actual activated volumes (derived from comparisons to baselines) per flexible resource and flexibility service provider as described in INTERFACE (2020).

Second, another issue is the rebound effect. Some stakeholders argue that an important share of the actions of independent aggregators affect only the timing of consumption and not the total volume of electricity consumed (Alba et al., 2021; NordREG, 2020; PA Consulting Group, 2016). For instance, when load reduction is associated with lower heating during peak hours, consumers may increase their heating above their classic consumption in off-peak hours to maintain the same comfort level. Broka and Baltputnis (2020) suggest, using simulations, that in the worst-case scenario, the financial impacts of the rebound effect on the supplier are considerable. They also find that putting these additional costs on the aggregators could significantly diminish or outright suspend their development. However, Broka and Baltputnis (2020) play down this worst case scenario, stating that costs could be more limited as not all technologies will create a strong rebound effect. The supplier, they argue, can learn how to best anticipate the rebound effect when being informed about DR activations. However, as is also recognised by NordREG (2020), this kind of learning and anticipation might take a long time and depends on how difficult forecasting will be in a system with higher renewables-based generation. Moreover, adapting forecasts and having to increase near real-time trading activity also imply costs for suppliers. Similarly, the rebound effect can affect the effectiveness of the perimeter correction, something stressed by Alba et al. (2021). More precisely, even if the perimeter of the supplier's BRP is corrected for the periods when the independent aggregator activates DR, there could be other hard-to-control imbalances occurring in the supplier's BRP portfolio just before or after DR activation due to the rebound effect.

A third issue is the accuracy of telemetry and of baseline definitions. Alba et al. (2021) remark that if the measurement is incorrect, the supplier's BRP can be affected by imbalances created by the independent aggregator even with a perimeter correction in place. The same issue holds for the supplier compensation if the (perceived) delivered energy by the independent aggregator is also used to determine the supplier's compensation. Regarding baselines, Bushnell et al. (2009) and Chao (2011) state that, unfortunately, individual customers will always know more about their true baseline than the administrator of a DR program. Customers can also profit from that knowledge. This "baseline problem", it is argued, can often be broken down into two classic difficulties that are found in markets where information is not complete: an adverse selection problem; and a moral hazard problem. The "baseline problem" is not specific to demand response via independent aggregation, but also to any form of DR without an intermediary based on administrative baselines.¹¹ Chao and Depillis (2013) propose a new baseline method, which prevents baseline inflation by establishing the customer baseline as a fixed proportion of a baseline based on aggregated consumption profiles. These authors show that by separating the individual's consumption from the baseline level the aggregate baseline approach can significantly weaken or eliminate the incentive to inflate the baseline. For a review of baseline methodologies, see for example Rossetto (2018) who sets out the different types of baseline methodologies that are used in the PJM power system in the US.

6. Conclusion and policy recommendations

The recently adopted EU Clean Energy Package calls upon Member States to develop a regulatory framework for independent aggregators. This means that all Member States need to come up with an answer to the following two issues. How can (i) the imbalances and (ii) the foregone revenues of the supplier caused by the actions of the independent aggregator be dealt with?

First, the imbalances of the supplier caused by the actions of the independent aggregator. This issue has not received much attention in the literature. The EU Member States that are most advanced in

¹¹ However, large grid users offering demand response without an intermediary would typically hold physical or financial positions rather than having the need for an administrative baseline. If large grid users are subject to an administrative baseline, their size makes it worth investing more resources in the monitoring of their baseline.

developing a regulatory framework for independent aggregators apply the same solution for this issue, namely, the perimeter correction. The perimeter correction can be applied to most products sold by independent aggregators, and could therefore become the target model for Europe that could be formalized via an amendment to the existing network code on balancing, i.e. the Electricity Balancing Guideline (EB GL), or via the expected Demand Side Flexibility Network Code or Guideline (DSF NC/GL).

Second, the supplier's foregone revenues. Most of the literature and the debate has focused on this issue. But there is no consensus on the need for compensation. The EU Member States that are most advanced in developing a regulatory framework for independent aggregators did introduce compensation models proxying energy sourcing costs. Examples here include Belgium, France, Germany (not implemented yet), Slovenia (not implemented yet) and Switzerland. While this is not the case for several countries outside of the EU such as the United States and Great Britain. In this paper, we categorize the compensation models that are currently applied in the EU Member States into regulated, corrected, and contracted models. Each compensation model has pros and cons. It is too early to say which one works best. It is difficult to have a discussion on harmonization before answering the most fundamental question, namely whether there is a need for a compensation.

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