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Finding an adequate level of compensation for demand-side flexibility

Assessment of possible market outcomes of different compensation mechanisms on independent aggregators and suppliers

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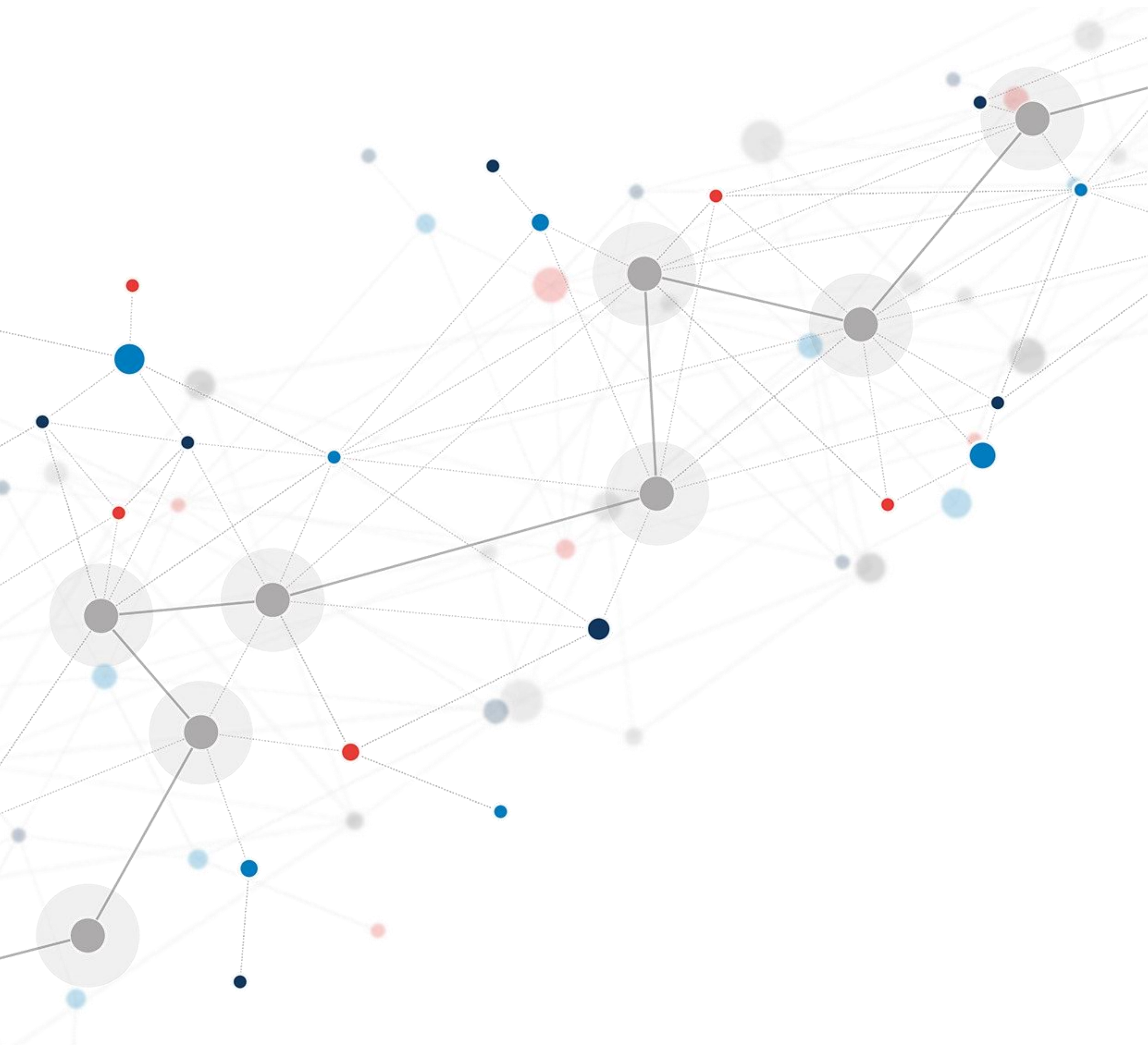
Non-confidential



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Executive summary

Context and objective of the study[1]

Demand-side flexibility (DSF) participation in the European electricity markets is currently limited due to a number of factors including the absence of adequate frameworks and the existence of barriers to independent aggregation. The Electricity Market Directive[2] specifies the key elements of the regulatory framework needed to foster demand response through aggregation, highlighting the aspects of financial compensation for demand response activation.

Where an aggregator is not at the same time the supplier of the customer offering flexibility, i.e. an independent aggregator (IA), rules related to DSF and balancing responsible parties (BRPs) must organise the transfer of energy (ToE), corresponding to the DSF activation volume, from the BRP of the consumer's supplier to the BRP of the IA. A compensation mechanism needs to be implemented to determine whether and how much the IA should compensate the customer's supplier for the ToE.

The type and level of compensation could affect suppliers, independent aggregators, and consumers differently. The compensation mechanism should therefore be designed in such a way that does not create barriers for market participants engaged in aggregation while covering the costs incurred by the suppliers of participating customers during the activation of demand response.

The Nordic Energy Regulators (NordREG) commissioned Compass Lexecon (CL) to conduct a study providing them insights on the most suitable compensation mechanism and level of compensation for independent aggregation in the Nordic context (Norway, Sweden, Finland, and Denmark).

Overview of the applied methodology

The applied methodology which enabled comparative and quantitative comparison of compensation approaches followed five main steps.

1. Definition of assessment criteria along six main categories: (i) impact on IAs, (ii) impact on suppliers, (iii) impact on electricity consumers, (iv) efficiency & distortions, (v) competition, and (vi) implementation.

[1] This report has been prepared by Compass Lexecon professionals. The views expressed in this report are those of the authors only and do not necessarily represent the views of Compass Lexecon, its management, its subsidiaries, its affiliates, its employees or clients.

The report is based on information available to Compass Lexecon at the time of writing of the report and does not take into account any new information. We accept no responsibility for updating the report or informing any recipient of the report of any such new information.

[2] Directive (EU) 2019/944 of the European Parliament and of the Council of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU (recast). Link.

2. Pre-screening of different levels of compensation (based on day-ahead, intraday, imbalance, and retail price) against the assessment criteria to select the most relevant options and discard those with evident distortions.

3. Quantitative assessment to analyse the impacts on suppliers and IAs for different DSF business models (energy activation and where applicable capacity reservation in DA, ID, and balancing reserves), for different types of flexible consumers (residential and industry players, with various DSF activation costs), for different types of retail offers (dynamic pricing, flat prices), for all Nordic bidding zones, and based on five historical years (2017-2021).

4. Comparison of the compensation options against the evaluation criteria based on the results of the quantitative analysis.

5. Conclusion on the pros and cons of different levels of compensation in the Nordic context.

Main findings

The quantitative results presented in Figure 1 indicate that **the most profitable market segments for DSF are by far the balancing reserves**, due to the significant share of capacity remuneration in the total revenues of IAs. This is true in the absence of compensation and even more when introducing a compensation mechanism, as Figure 1 illustrates with the example of a compensation at the day-ahead price. This, however, strongly depends on the ability of DSF resources to meet the technical requirements to provide such balancing reserves.

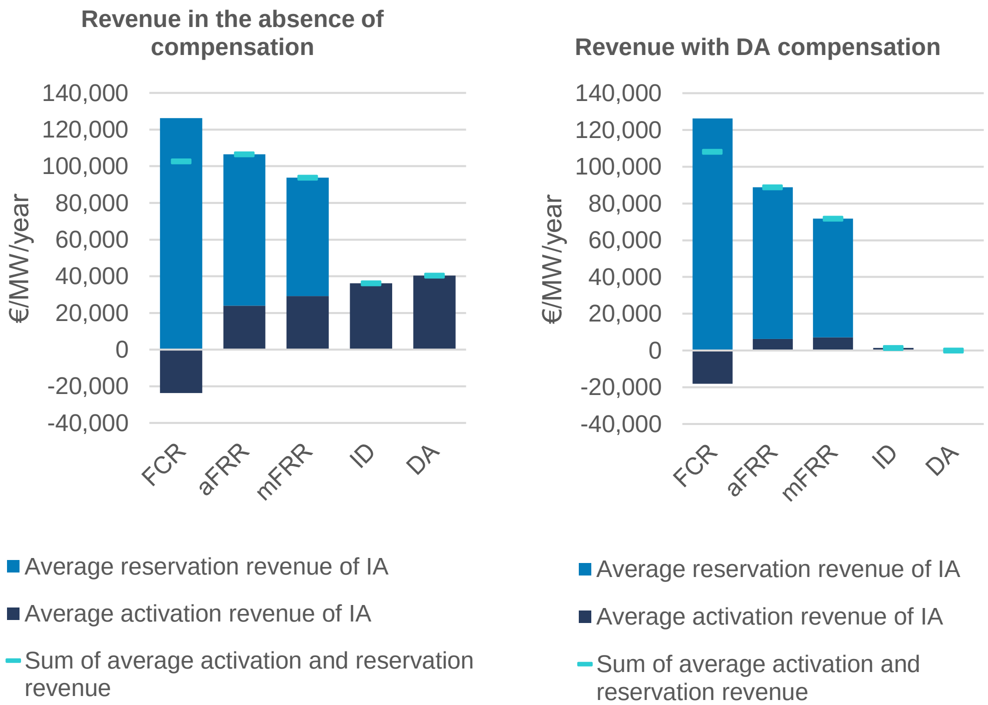


Figure 1 – Revenue of IA for a portfolio of electric vehicles (EVs), in the absence of compensation (left) and with a compensation based on day-ahead prices (right)

Note: average of bidding zones and of years 2017-2021, for a portfolio of EVs whose activation is driven by timing constraints. DK1 and DK2 are not included in the aFRR average reservation revenue due to limited available data in ENTSO-E dataset. DK2 is not included in the aFRR average activation revenue for the same reason. Swedish bidding zones are not included in the mFRR average reservation revenue calculation due the absence of mFRR capacity remuneration in Sweden.
Source: CL analysis based on data from ENTSO-E (FCR, FRR, DA) and Ei (ID).

Impact on IAs

Figure 1 also shows that, whereas **the introduction of ToE compensation could hinder the profitability of DSF participation in pure energy markets like the day-ahead (DA) and intraday (ID) markets**, **IA revenues in balancing reserves remain significant** despite ToE compensation thanks to capacity remuneration.

The quantitative analysis also indicates, on the basis of the assumptions defined with NordREG, that industrial DSF in any case has a lower frequency of activation (see Figure 2) due to high activation costs. It may thus be less sensitive to the compensation level than residential DSF.

In the recent years though, the energy crisis has increased volatility and security of supply concerns in the market. Therefore, despite the introduction of ToE compensation, there could still be significant value for IAs in participating in day-ahead and intraday markets. However, compensation based on day-ahead, intraday or imbalance prices would act as a barrier to their participation as it strongly reduces the value IAs could capture in those markets and makes their participation risky when the compensation price is not known in advance.

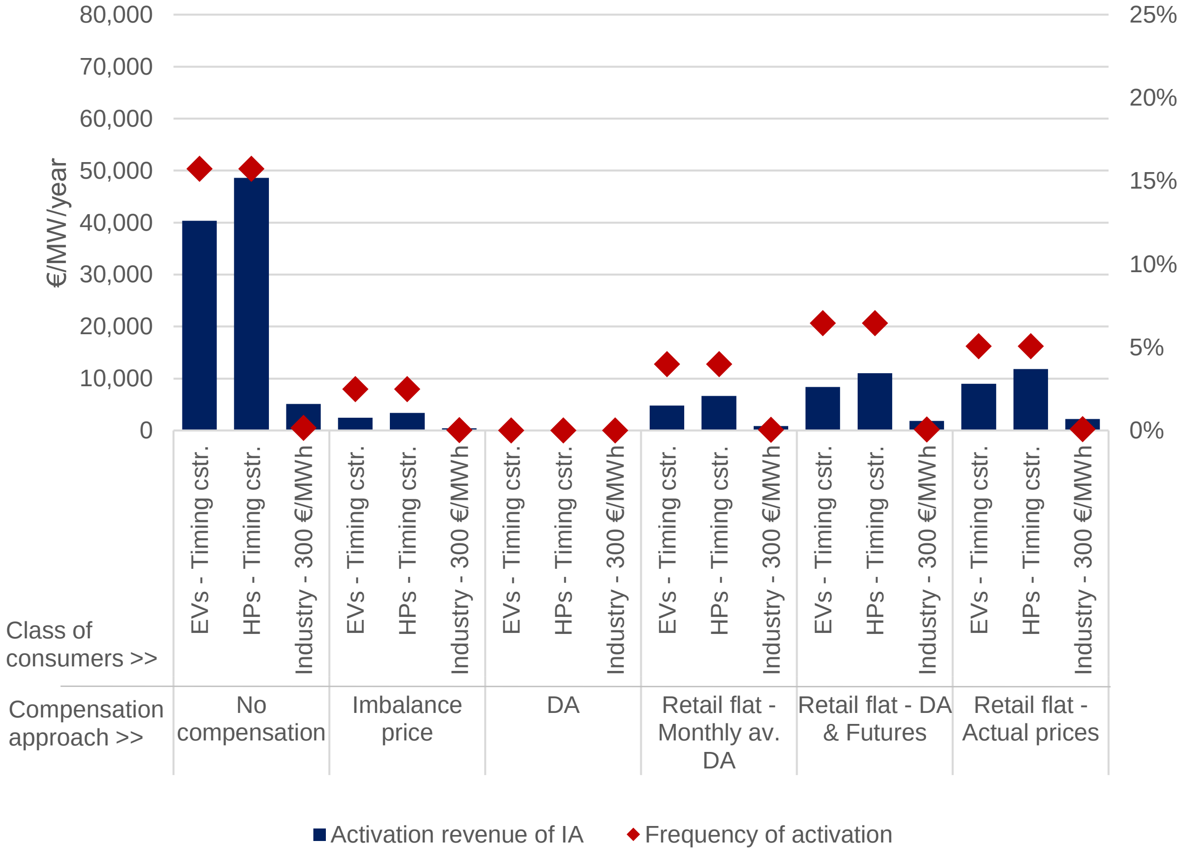


Figure 2 – Revenue of IA and frequency of activation in the DA market for different activation constraints on EVs, HPs and industrial consumers

Note: average revenue of IA and average frequency of activation in the DA market for all bidding zones and for 2017-2021, for HPs and EVs with time-based activation constraints, and for industrial consumers with an opportunity cost of 300€/MWh, depending on the level of compensation.
Source: CL analysis based on data from ENTSO-E (FCR, FRR, DA) and Ei (ID).

Impact on suppliers

If the compensation price is set at the actual retail price of the consumers, there is no impact on suppliers. Capturing the exact retail price would be, however, impossible or very difficult in practice.

The introduction of a compensation associated with the ToE reduces the impact on suppliers – which can be positive or negative – no matter what the choice of the level of compensation (see Figure 3). The diversification of the suppliers' portfolio of customers can balance this impact further if they offer varied types of retail offers. Conversely, in case there is no compensation for the ToE, the negative impact on suppliers could be significant at up to -6% of their revenues.

Lastly, a more substantial impact appears for suppliers with dynamic pricing if the compensation is based on a flat retail price, while DA price compensation fully neutralises this impact. In general, DA price compensation limits the impact on suppliers as it strongly reduces the frequency of DSF activation.

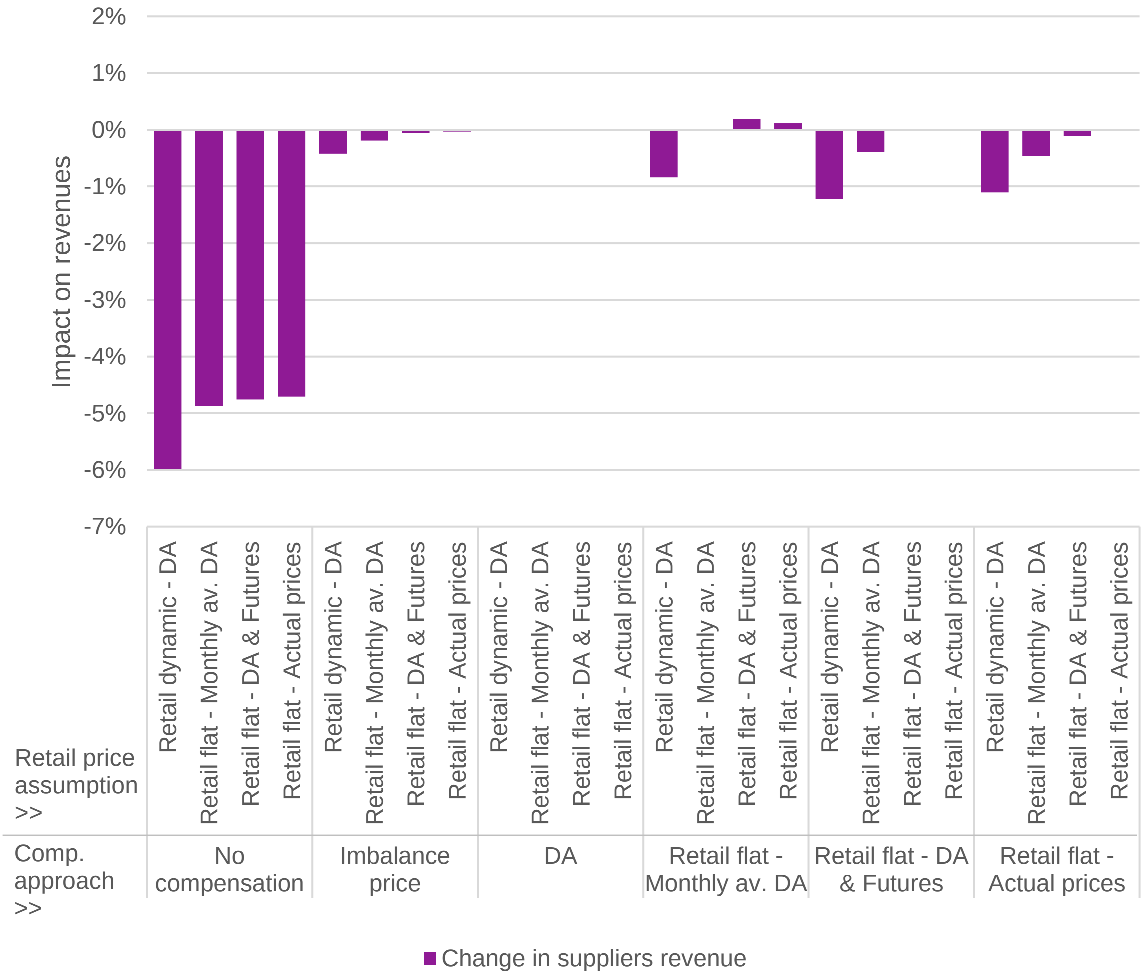


Figure 3 – Impact on suppliers' revenues from participating consumers due to activation in DA

Note: average change in supplier's revenues for all bidding zones, for 2017-2021 and for 3 types of consumers (HPs / EVs with time-based activation constraints, and industrial consumers with an opportunity cost of 300€/MWh), depending on the retail price estimation approach and on the level of compensation.
Source: CL analysis based on data from ENTSO-E (FCR, FRR, DA) and Ei (ID).

Suppliers might also be impacted outside of flexibility activation periods by the rebound effect, depending on the way the latter is considered in the compensation mechanism. The rebound effect is not quantitatively assessed in this study, and could be either be positive or negative, depending on the approach followed.

Impact on electricity consumers

An inadequate compensation level could reduce possibilities for consumers to value their flexibility or could make their electricity bills more expensive.

On the one hand, compensation which is too low may prevent flexible consumers from benefitting from the most attractive retail prices. On the other hand, compensation which is too high would deter IAs from providing flexibility services to consumers.

Moreover, setting the compensation at the DA, the ID or the imbalance price would prevent certain consumers from valuing their flexibility in pure energy markets. Indeed, the compensation would in this case reflect the short-term volatility of prices, which would hinder the profitability of DSF activation, and in turn hinder the profitability of DSF participation in pure energy markets. Consumers with flat retail prices would therefore lose the opportunity to value their flexibility in such markets through IAs.

Efficiency and distortions

Perfect estimation of retail prices for the ToE would theoretically lead to efficient activation of flexibility in all timeframes. However, the exercise is complex in practice and significant misestimation would distort the costs and volumes of flexibility offered.

Setting the ToE at the DA, the ID or the imbalance price would hinder the profitability of DSF activation, and IAs might therefore not respond to energy price peaks. Conversely, the absence of compensation implies a risk of overactivation, as the activation cost does not account for the energy sourcing cost.

Impact on competition

While the absence of compensation could have considerable negative impact on suppliers, a ToE compensation based on the DA, ID or imbalance price would limit opportunities for IAs and potentially create barriers to their participation in some of these markets.

Compensation at the retail price would in theory create a level playing field between suppliers and IAs for the provision of flexibility services. Biases could lead to a more favourable approach for IAs or for suppliers, or for certain suppliers depending on their main retail price offers. However, these biases may not have significant implications.

When most consumers have dynamic pricing retail offers, the most adapted proxy for the retail prices would converge towards the day-ahead price, guaranteeing an adequate level playing field.

Implementation issues

The no compensation approach and, to a large extent, approaches based on DA, ID or imbalance prices do not raise major implementation issues but could face the risk of strong opposition by interested parties, either the IAs or the suppliers.

Conversely, compared with other approaches, **compensation based on retail prices raises complex questions** to address in order to define a good and robust methodology to estimate the adequate retail price. However, given the relatively limited impact of getting it wrong on IAs and suppliers, an acceptable methodology could be found. Once defined, the implementation of such a simplified methodology should not raise major difficulties.

Table 1 presents a visual summary of the evaluation of different compensation approaches against assessment criteria developed in this study.

Table 1 – Summary of the main findings

Category	Criteria	No compensation	Day-ahead price	Intraday price	Imbalance price	Retail price
1. Impact on IAs	1.1. Impact on IA revenues					
	1.2. Impact on DSF development					
2. Impact on suppliers	2.1. Expected financial impact compared with status-quo					
	2.2. Variability given the range of retail offers					
3. Impact on electricity consumers	3.1. Impact on flexibility offers proposed to final consumers					
4. Efficiency /distortions	4.1. Impact on DSF activation					
	4.2. Impact on price formation					
5. Competition	5.1. Impact on competition between suppliers and IAs					
6. Implementation	6.1. Complexity of implementation					
	6.2. Replicability and contestability					

Note: the predominance of certain types of offers in a given market, e.g. dynamic pricing, could modify this analysis.
Source: CL analysis.

Conclusions

Compensation reflecting retail prices would be the most suitable approach, but the **estimation of retail prices is complex** and subject to errors.

Compensation based on day-ahead prices could reflect adequately retail prices for a large share of consumers in the Nordic countries and therefore **be a relevant option to consider, especially in countries where dynamic pricing** based on day-ahead prices is widespread amongst consumers or for most industrial consumers.

However, if applied **in situations where most consumers would have non-variable retail prices** (or would not be metered on an hourly basis), **using the day-ahead prices could act as a barrier**

to the participation of DSF in pure energy markets such as the DA or the ID. Consumers would have no incentives to value their flexibility in such markets, either through retail price signals, or through IAs. In such scenarios, a compensation price based on a blend of day-ahead prices and flat retail price estimates, taking into account the actual proportion of dynamic pricing penetration, could be a more adapted solution. As regards balancing markets on the other hand, given the high proportion of capacity remuneration, the negative impact of using the day-ahead prices for the compensation on IA revenues would likely be limited.

Introduction

Context and background

Currently, demand-side flexibility (DSF) participation in the European electricity markets is limited, due to a number of factors including the absence of adequate frameworks or the existence of barriers to independent aggregation.

Therefore, and in accordance with the directive (EU) 2019/944 on common rules for the internal market for electricity,[3] EU member states need to implement frameworks to enable independent aggregation. An independent aggregator (IA) is an aggregator of DSF different from the electricity supplier of the consumer and who operates without consent from or a contract with this supplier. In such a setup, the rules applicable to balancing responsible parties (BRPs) must organise the transfer of energy (ToE), corresponding to the DSF activation volume, from the BRP of the consumer's supplier to the BRP of the IA. The compensation mechanism via which the IA compensates the supplier for ToE is a central concept.

Article 17(3) of the Electricity Market Directive specifies the key elements of the regulatory framework needed to foster demand response through aggregation. In particular, it states that **financial compensation for demand response activation** shall:

- not create a barrier to market entry for market participants engaged in aggregation or a barrier to flexibility; and
- shall be strictly limited to covering the resulting costs incurred by the suppliers of participating customers or the suppliers' BRPs during the activation of demand response.

ACER's draft Framework Guideline on Demand Response (ACER, 2022) sheds light on the objectives, principles, processes, definitions, and high-level requirements of demand response. With respect to compensation mechanisms, Section 2.2 specifies that:

- the compensation is considered to be independent from any correction that is deemed necessary in the volumes attributed to the respective BRP(s) in the context of the imbalance settlement;
- the new rules shall specify whether the payer of the transaction is the independent aggregator or the final customer, although in both cases the receiver of the compensation is the supplier of the final customer; and
- the new rules shall ensure that the financial compensation is not creating a barrier for market participants engaged in aggregation.

The above-described context underlines the importance of defining a compensation mechanism which is appropriate, non-distortive and non-discriminatory for the key market participants – suppliers, independent aggregators, and final customers.

[3] Directive (EU) 2019/944 of the European Parliament and of the Council of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU (recast). Link.

Scope and objectives

The Nordic Energy Regulators (NordREG) are seeking to find an adequate level of compensation for independent aggregation. NordREG commissioned Compass Lexecon to study possible market outcomes for different compensation mechanisms with different levels of remuneration in the electricity markets of four Nordic countries (Norway, Sweden, Finland, and Denmark). The goal is to find a level of compensation that can be considered fair and which does not lead to under- or overcompensation.

Several compensation mechanisms, such as uncorrected, corrected, and central settlement models, have been implemented in Europe. NordREG appointed Compass Lexecon to conduct the following comparative and quantitative analysis within the central settlement model setup:

1. Analyse the effects of different levels of compensation on the aggregators, as well as the suppliers, including the extreme cases with no compensation and overcompensation;
2. Analyse what the different levels of compensation would mean for the amount of flexibility offered to the markets; and
3. Assess the pros and cons of different levels of compensation in the Nordic context.

The purpose of the study is to provide NordREG with insights on the most suitable compensation mechanism and level of compensation for independent aggregation in the Nordic context.

It is important to note that the report relies on public information and information communicated during interviews, and also requires a number of assumptions agreed with NordREG. The quantitative analysis is based on a simplified modelling of DSF, as described in detail in Section 2, which may not fully reflect all consumer characteristics or possible participation strategies, or all retailers' approaches.

Structure of the report

The remainder of the report is structured along four main parts:

- Part 1 - Identification of options for the compensation mechanism;
- Part 2 - Methodology for the assessment of the options;
- Part 3 - Analysis of the compensation approaches;
- Part 4 - Conclusions.

1 Identification of options for the compensation mechanism

Where the aggregator is not also the supplier of the customer engaged in demand response, rules applicable to balancing responsible parties (BRPs) must organise the ToE. The ToE corresponds to the volume of activated DSF, transferred between the BRP of the consumer's supplier and the BRP of the IA. Moreover, a compensation mechanism determines how much an IA needs to compensate the customer's supplier for the energy component when flexibility[4] is activated.

This section summarises the key issues regarding the implementation of a compensation mechanism between independent aggregators and suppliers, and briefly presents different possible options, some of which have been implemented in Europe.

1.1 Why do we need a compensation mechanism?

During DSF activation periods, IAs value a volume of activated flexibility in electricity markets. In the case of upward activation, the volume of flexibility corresponds to the energy not consumed by the client, and in the case of downward activation, it corresponds to the surplus of energy consumed.

When upward flexibility is activated (i.e. consumption is reduced), IAs source energy from suppliers to sell it in electricity markets. In the absence of balancing perimeter correction and compensation mechanisms, upward DSF activation impacts suppliers in several ways, while IAs would source the energy freely. Firstly, DSF activation impacts the **balancing position** of the supplier, as the actual consumption of the supplier's client differs from what was expected ahead of real time. The supplier might in turn face imbalance costs or receive compensation (DNV GL, 2020), depending on whether the activation helps or deteriorates system adequacy between supply and demand. However, suppliers should in principle receive money through the imbalance settlement in this situation, as BRPs receive the imbalance settlement price for positive imbalances.[5] Secondly, DSF activation impacts the **sourcing position** of the supplier. Indeed, DSF activation prevents suppliers from selling to consumers energy that has previously been sourced ahead of real time. Suppliers are unable to pass on sourcing costs to end-users as they would normally do outside activation periods. Energy sourced ahead of real time for the consumption of the client during the DSF activation period cannot be recovered at the retail price.

Figure 4 summarises these two impacts. These two effects are balanced in terms of energy volume, but they might not be fully balanced financially due to the difference between the imbalance price (revenue) and the retail price (cost). This is similar to a situation where the consumer decided independently not to consume.

[4] This situation corresponds to upward activation. Similarly, downward activation involves a ToE from the IA to the consumer's supplier, and compensation mechanisms determine how much a supplier needs to compensate the IA for the energy transferred.

[5] Also note that imbalance prices are unlikely to be negative insofar as DSF is likely activated when there is a need for additional supply to meet demand, and therefore higher prices. DSF activation could also reduce a negative imbalance: the BRP of the supplier would therefore avoid paying the negative imbalance price for the corresponding volume.

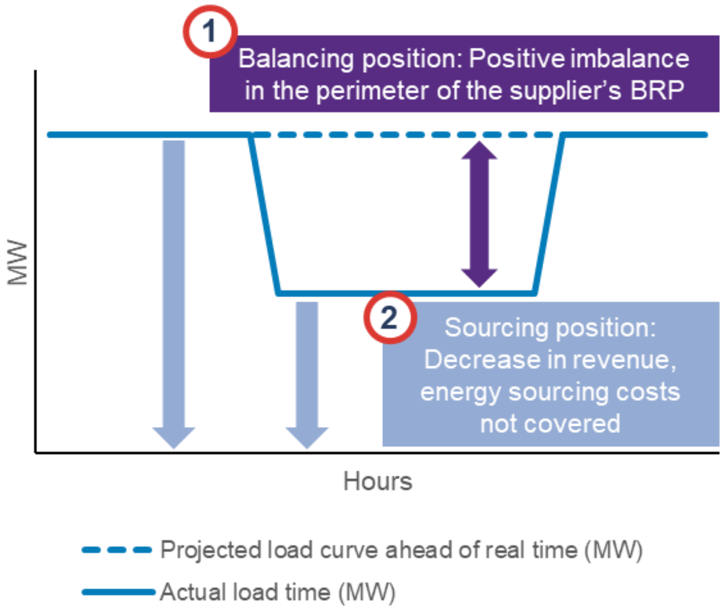


Figure 4 – Illustration of the impact of upward DSF activation on suppliers

Source: CL analysis.

When downward flexibility is activated, suppliers source energy from IAs to sell it to consumers. In the absence of balancing perimeter correction and compensation mechanisms, conversely to upward activation, downward activation of DSF induces a higher demand in the perimeter of the Suppliers' BRP portfolio and therefore a negative imbalance (or a lower positive imbalance) on its perimeter. The BRP of the supplier therefore faces imbalance costs corresponding to the DSF volume multiplied by the imbalance settlement price. On the other hand, the load of the consumer temporarily increases compared with what was previously expected. This has a positive impact on the revenue captured by suppliers. Similarly to upward activation, these two effects are balanced in terms of energy volume, but they might not be fully balanced financially due to the difference between the imbalance price (which would be a cost here) and the retail price (which would be revenue). It is similar to a situation where the consumer independently decided to consume more.

The introduction of the transfer of energy between the BRPs of the IAs, and of the suppliers, and of an associated compensation mechanism, recognises the implicit transaction of energy between the supplier and the IAs. Compensation mechanisms explore how and how much suppliers should be compensated during flexibility activation periods. Several compensation models have been implemented in Europe (see Table 2), with both benefits and drawbacks. In the uncorrected model, the IA is not responsible for the imbalances it causes in the system: the perimeter of the supplier's BRP is not corrected, and the supplier is implicitly compensated through the balancing mechanism. In the corrected model, the BRP associated with the IA is responsible for the imbalance it causes: the supplier bills the customer as if no flexibility had been activated, and the customer is compensated by the IA to cover the energy invoiced but not consumed.

As mentioned in the Introduction, NordREG mandated Compass Lexecon to analyse the compensation mechanism in a central settlement model. This model is described in section 1.2.

Table 2 – Compensation models implemented in selected European countries

	FCR	aFRR	mFRR & RR	DA	Capacity market
Belgium	Uncorrected	Corrected*	Corrected* / Central settlement		
Finland	Uncorrected (FCR-D/FFR) Central settlement (FCR-N)		Central settlement (pilot stage)		
Germany	Uncorrected	Corrected			
France	Uncorrected		Corrected / Central settlement		
Switzerland	Uncorrected	Central settlement			

Source: CL analysis based on (DNV GL, 2022).

1.2 Identification and description of compensation mechanisms

In the central settlement model, both the balancing and the sourcing positions of the suppliers are corrected.

Regarding the balancing position, the BRP associated with the IA is responsible for the imbalance it causes in the perimeter of suppliers when activating flexibility. During demand-side flexibility activation periods, a central entity corrects the perimeters of both the supplier's and the IA's BRP. This correction neutralises the imbalance created in the perimeter of the supplier's BRP.

Moreover, regarding the sourcing position, a volume of energy is transferred between suppliers and IAs by a central entity, the so-called "Transfer of energy" (ToE), associated with a certain level of compensation. During upward activation, a block of energy is transferred from the supplier to the IA, and the IA pays for this energy sourced, as described in Figure 5. Similarly, during downward activation, a block of energy sourced by the IA is transferred to the supplier, for which the IA receives a compensation from the latter, as described in Figure 5.

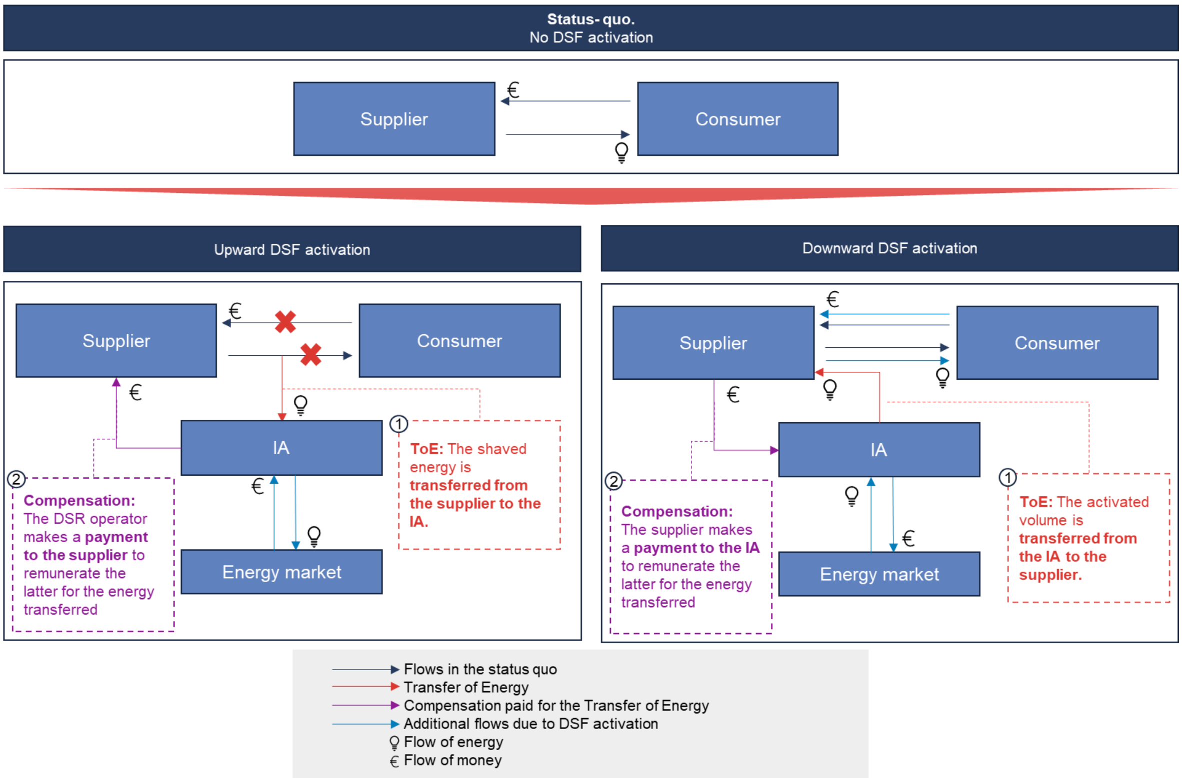


Figure 5 – Transfer of Energy (ToE) during DSF activation

Source: CL analysis.

In this model, market rules must define the compensation for the ToE, paid by the IA to the supplier. Table 3 presents different approaches to define the level of ToE compensation.

Table 3 – Selected compensation approaches to define the level of ToE

#	Level of compensation	Description of the option
1	**No compensation**	• No payment associated with the ToE
2	**Day-ahead price**	• Hourly price published by the NEMO in D-1 for a given time unit and a given bidding zone • Already implemented in Switzerland for aFRR and mFRR, and in Finland for mFRR
3	**Intraday price**	• Hourly price published by the NEMO in D for a given time unit and a given bidding zone
4	**Imbalance price**	• Hourly price published by the TSOs for a given time unit and a given bidding zone • Similar to the uncorrected model • Already implemented in Finland for FCR-N
5	**Retail price**	• The compensation price is based on a formula set by the appointed authority, to reflect the retail price. This formula could be based on market indices, typically forward products and day-ahead price • Already implemented in Belgium and France

Source: CL analysis based on (DNV GL, 2020), (DNV GL, 2022).

This report will compare these approaches and their impacts on the main concerned stakeholders and analyse the appropriateness of their implementation in the Nordic markets.

2 Methodology for the assessment of the options

The scope of work of the study is to conduct a comparative and quantitative analysis of different compensation level options within the central settlement model setup, aiming to:

1. analyse the effects of different levels of compensation on the aggregators, as well as the suppliers, including the extreme cases with no compensation and overcompensation;
2. analyse what the different levels of compensation would mean for the amount of flexibility offered to the markets; and
3. assess the pros and cons of different levels of compensation in the Nordic context.

The objective of this section is to give an overview of the methodology applied in this study, with a focus on the quantitative assessment and on the key modelling assumptions.

2.1 Overview of applied methodology

The approach detailed in Figure 6 is used in this study to compare compensation approaches and conclude on a preferred compensation approach. The following five steps are carried out:

1. Definition of assessment criteria to compare the compensation approaches
2. Pre-screening of a range of levels of compensation against the assessment criteria to select the most relevant options
3. Quantitative assessment of the selected options
4. Detailed comparison of the options in the light of the results of the quantitative analysis and the evaluation criteria
5. Conclusion on the pros and cons of different levels of compensation in the Nordic context

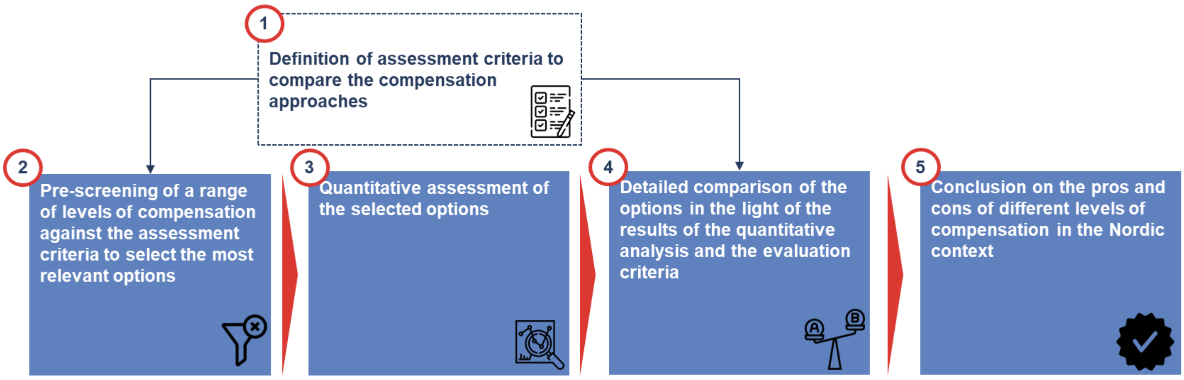


Figure 6 – Overview of the methodology

Source: CL analysis.

The three first steps are outlined below, and section 2.2 details further the quantitative assessment and its underlying assumptions.

It should be also noted that we have directly contacted more than 10 companies across the Nordic countries and asked for an interview on their retailing and pricing practice. However, only one company answered our request and was interviewed. Moreover, our analysis is also based on past projects on retail pricing and DSF and experiences with suppliers, consumers, aggregators, and regulators in various European countries.

2.1.1 Definition of assessment criteria

Table 4 – Comparative framework for the analysis

Category	Criteria	Underlying questions
1. Impact on Independent Aggregators	1.1. Impact on IA revenues	• How much net revenue (in X€/MW/year) can IAs expect through DSF activation? • Are there any other major sources of income for DSF operators (e.g. balancing reserves)?
	1.2. Impact on DSF development	• Are revenues under the different compensation scheme sufficient to allow DSF development?
2. Impact on suppliers	2.1. Expected financial impact on suppliers compared with status-quo	• What change in supplier's revenue compared with a situation with no DSF activation?
	2.2. Variability given the range of retail offers	• What is the distribution of the impact among suppliers, depending on the type of retail offers? Dynamic, Time-of-Use (ToU) or flat price, etc?
3. Impact on electricity consumers	3.1. Impact on flexibility offers proposed to final consumers	• Does the compensation mechanism prevent/ deter IAs or suppliers from proposing certain types of offers to final electricity consumers?
4. Efficiency /distortions	4.1. Impact on DSF activation	• Does the price signal sent to IAs and to consumers contribute to efficient DSF activation? Or is there a risk of under-/over-activation of the DSF?
	4.2. Impact on price formation	• Does it risk affecting price formation in the market?
5. Competition	5.1. Impact on competition between suppliers or IAs regarding the provision of DSF?	• Does the compensation scheme unduly favour certain suppliers compared with others or suppliers compared with IAs or conversely regarding the provision of DSF offers?
6. Implementation	6.1. Complexity of implementation	• How complex are the ToE calculation rules?
	6.2. Replicability and contestability	• Is the methodology clear, transparent, and replicable? Could it raise legal challenges?

Source: CL analysis.

The selected levels of compensation can be qualitatively and quantitatively compared against several criteria of analysis, as shown in Table 4. The purpose of this comparative analysis framework is twofold in the context of this study: (i) Conducting a qualitative pre-screening of a list of ToE compensation levels, to select only the most relevant approaches, (ii) Conducting a detailed analysis of the selected compensation levels using the outputs of the quantitative impact assessment, in order to conclude on a preferred level of compensation.

2.1.2 Pre-screening of the options to identify which to model

The purpose of this task is to discard approaches that would induce evident distortions, and to select the most relevant approaches on which to carry out a more detailed quantitative analysis. To this end, a qualitative analysis is conducted with simple economic reasoning, against the assessment criteria defined above.

2.1.3 Quantitative assessment

The aim is to enrich the comparative analysis with a quantitative assessment of the impact of the selected levels of compensation. Referring to the comparative framework defined in Table 4, the quantitative assessment will mainly focus on the following criteria:

- **Criteria 1.1 – Impact on IA revenues.** The aim is to estimate the total net revenue (after compensation payment, in €/MW/year) IAs could generate through DSF activation/availability, for each level of compensation.
- **Criteria 1.2 – Impact on DSF development.** The estimation of yearly revenues of IAs, under the different levels of compensation, can then be compared with typical minimum revenue requirements to assess whether DSF would be able to develop under such conditions.
- **Criteria 2.1 – Expected financial impact on suppliers compared with status-quo.** The goal is to estimate the relative change in revenue each level of compensation incurs compared with a status quo with no DSF activation.
- **Criteria 2.2 – Variability given the range of retail offers.** The impact on suppliers can differ depending on the type of retail offers (e.g. dynamic price, ToU price, flat price). This can be captured by quantifying the variation of the impact between such offers.

Moreover, the results of the quantitative analysis can also support the analysis of the other criteria when relevant.

2.1.4 Analysis of the options against the assessment criteria and recommendation of a preferred compensation approach

Each level of compensation described in Table 3 can then be assessed against the analysis criteria defined in Table 4, leveraging the output of the quantitative assessment. This comparative assessment is then used to conclude on a preferred compensation approach.

2.2 Description of the quantitative assessment

This section first describes the applied quantitative methodology (step 3 of the applied methodology) followed by definitions of assumptions used in the quantitative assessment.

2.2.1 Description of the quantitative assessment methodology

Quantification of the impact of suppliers' compensation approaches on the business case of aggregators and suppliers (criteria 1.1, 2.1 and 2.2)

For each compensation approach, this study quantifies the impact on the business case of both IAs and suppliers, for a given capacity of a flexible asset.

Regarding the financial impact on IAs (criteria 1.1), the aim is to estimate the total net revenue IAs could capture in each market segment, depending on the compensation approach followed. In the rest of the study, net revenue is defined as the difference between gross revenue from DSF operation, and activation/reservation costs (except when these are opportunity costs).

Revenues of IAs consist of energy revenues, stemming from DSF activation both in energy markets and for balancing reserves, and capacity revenues from reservation in balancing reserves. Moreover, revenues can be generated with both upward and downward products. In this study, yearly IAs' energy and capacity net revenues are derived from historical electricity market prices, and calculated at an hourly time step thanks to the following approach:

1. **To estimate the energy net revenues**, DSF is assumed to be activated in each market when it can derive a direct benefit from it. It corresponds to a situation when the gross revenues the IA can capture for a given hour are higher than the sum of activation costs and opportunity costs.[6] In the case of upward activation, the gross revenues are the revenues from the sale of flexibility at the energy market price while activation costs are the sum of the ToE compensation and of the technical activation cost. Conversely, the gross revenues for downward activation correspond to the ToE compensation, and activation costs for both energy sourcing and technical activation.

2. **To estimate the capacity net revenues** (applicable for balancing reserves involving capacity payments), DSF capacity is assumed to be reserved when the capacity market price is above the reservation cost. The capacity revenues resulting from DSF availability are then calculated for each hour in a year as the product of the reserved volume and the difference between the capacity market price and the reservation cost. Capacity revenues are thus not directly impacted by the level of compensation, which is the focus of this report. Nonetheless it is interesting to estimate its share in the total revenues of IAs to fully understand the impact of compensation mechanisms on the business case of IAs.

Regarding the financial impact on suppliers (criteria 2.1. and 2.2), the aim is to estimate the relative change in revenues each level of compensation incurs compared with the status quo with no DSF activation. The revenues in the status quo can be calculated assuming a yearly baseline consumption profile, before DSF activation, and a typical level of retail price and structure. These can then be compared with the revenues after DSF activation: when flexibility is activated, the activated volume is valued at the compensation price rather than at the retail price.

[6] This approach is used for market places in which marginal activation is assumed, i.e. the DA and the ID market, and the aFRR and the mFRR reserves.

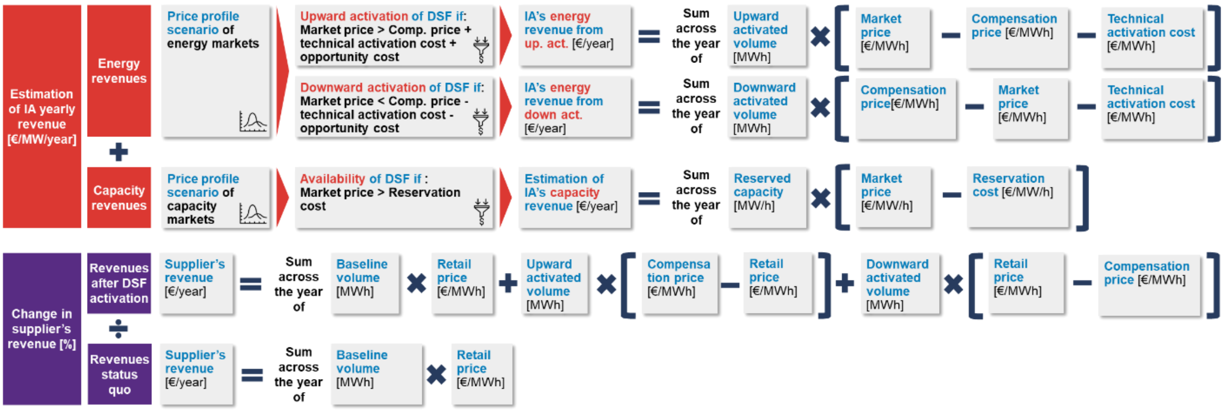


Figure 7 – Overview of modelling methodology to quantify the impact of compensation approaches on the business case of IAs and suppliers

Source: CL analysis.

To have a grasp on the full range of situations, the impact on both suppliers and IAs needs to be calculated for different **DSF business models** (participation in DA, ID, balancing reserves), for different types of **flexible consumers** (residential and industry consumers, with various DSF activation costs), for different types of **retail offers** (dynamic pricing, flat prices), and for all the **Nordic bidding zones** based on several historical years**.**

Quantification of the impact of suppliers' compensation approaches on the flexibility offered on the market (criteria 1.2)

The estimation of yearly revenues of IAs, under the different levels of compensation, can then be compared with typical minimum revenue requirements found in the literature to assess whether a DSF would be able to develop under such conditions.

2.2.2 Definition of modelling assumptions

DSF technical & economic constraints

The impact of the ToE is modelled on the participation of three typical IAs, each of them characterised by a typical portfolio of flexible consumption assets: (i) Electric Vehicles (EVs), (ii) Heat Pumps (HPs) – used as types of residential or professional consumers' flexibility – and (iii) Industrial consumers, as shown in Table 5.

Both EVs and HPs are assumed to have similar activation constraints. In each case, two different methods are used and then compared with reflect different value of the flexibility stock (i.e. the fact that electricity consumers may not be willing to change their load during any time of the day and ultimately need to charge their vehicle or heat their house; not applicable for participation in FCR, which only involves up and down activations, the sum of which tends to be zero, with therefore no associated stock issue):

- **Method 1 –** No opportunity cost, as residential consumers are not directly involved in goods and services production activities**.** However, the placement of the activation periods takes into account timing constraints: for both upward and downward products, DSF flexibility can only be activated for two hours during the day and two hours during the night, when the portfolio's revenue is maximised. A technical activation cost of 10€/MWh is assumed, aligned with typical values found in the literature (European Commission, 2016), reflecting the difficulty for an aggregator to activate a large number of consumers at the same time.

- **Method 2 –** Opportunity cost aligned with activation costs found in the literature for industrial consumers (typically 200€/MWh), reflecting the value of the flexibility stock. A technical activation cost of 10€/MWh is also assumed, as for method 1.

For industrial consumers, no technical activation costs are assumed as DSF activation typically involves a more limited number of sites than for residential consumers. Moreover, no timing constraints are assumed as consumption typically occurs all day long, with a larger flexibility stock, even though this may differ in practice between consumers. However, different values of opportunity costs are assumed, to reflect the variety of types of industrial activities.

Regarding reservation constraints, the reservation cost of DSF is assumed to be zero for each type of consumers. Indeed, DSF reservation involves in this study a limited risk of unavailability for which to hedge, as only shorter-term capacity products close to real time are simulated (up to 1 week).

Specific seasonal and hourly derating factors are applied for each class of consumers, reflecting their level of consumption within a year / day, as shown in Table 5.[7] EVs are assumed to mostly charge overnight, and HPs' potential is assumed to be mostly available during winter (consumption from air and water heating), rather than throughout summer (consumption from water heating and air cooling via air conditioning). Industrial consumers are assumed to be active all year long, with only some weeks of maintenance.

[7] Note that a MW of DSF in our study may not correspond to the full technical DSF capacity but may take an implicit de-rating factor reflecting the aggregation and addressing the risks that not all individual capacities within the pool of participating consumers might be available simultaneously and all the time. It is thus up to the IAs to pool resources so that they can provide a firm MW in the various market segments considered in the study.

Table 5 – Key modelling assumptions regarding DSF technical and economic constraints

Typical portfolio	Opportunity cost	Technical activation cost	Timing constraints	Reservation cost	Seasonal/hourly de-rating factor	Ability to provide upward and/or downward flexibility
EVs	**Method 1: 0€/MWh**; **Method 2:** activation cost of **200€/MWh**	**10€/MWh**	**Method 1:** Activation during the 2 hours of the day / night which maximise the portfolio's revenues **Method 2:** No timing constraints	**0€/MW/h**	**Mostly available overnight** - 100% during the night - 50% during the day (5h-16h)	Upward & downward activation in balancing reserves, only upward in the DA and ID market
HPs					**Mostly available during winter:** - 100% during winter - 50% during summer	
Industry	**200-300-500-1000€/MWh**	**0€/MWh**			**Available all year long:** - 95% all year long	

Source: CL analysis based on (Lennart Söder, 2018) (European Commission, 2016) (RTE, 2017) (SmartEn, DNV , 2022) (Carbon Trust, Imperial College London Consultants, 2021).

DSF business model

In the context of the study, IAs are considered active in the following markets: DA, ID, FCR, aFRR, mFRR. Simplifications are used regarding the design of the balancing reserves, despite current differences across countries (differences are expected to gradually disappear with the deployment of European balancing platforms, e.g. PICASSO, MARI).Activation and reservation in the balancing reserves are modelled at an hourly step. Regarding aFRR and mFRR, free bids and asymmetrical products are assumed to be allowed, and activation is modelled based on merit-order. Pro-rata activation is assumed for FCR: all reserved capacities are activated in parallel, proportionally to the needs of the system.

Moreover, the participation of IAs in each of the markets is modelled separately, without taking into account any potential arbitrage strategy. However, in practice, IAs may maximise their profits by participating in various schemes depending on the expected revenues at a certain point in time compared to the others.

The quantitative assessment takes into account the different bidding zones within Denmark, Finland, Norway and Sweden.[8] However, local flexibility platforms and redispatching markets are not considered in this assessment due either to the lack of liquidity and price reference or the unavailability of granular data, and due to the local constraints in finding and pooling DSF capacities at a very local level.

Market price scenario

This quantitative analysis is based on hourly historical price data for the markets considered. The impact of compensation levels on market players is assessed against an annual profile of historical

[8] Twelve bidding zones in total: DK1, DK2, FI, NO1, NO2, NO3, NO4, NO5, SE1, SE2, SE3, SE4.

prices, corresponding to the years 2017-2021. Data for 2022 are also used to run specific sensitivity tests. The appendix provides the detail of data and sources.

Retail offers from suppliers

The Nordic electricity retail market shows a strong predominance of certain types of electricity retail contracts, notably fixed flat contracts and hourly spot dynamic contracts as shown in Table 6 and which we aim to approximate in this study. The purpose of these retail price estimates is twofold: they are used as price references of the ToE compensation approaches, and to assess the impact of DSF activation on suppliers, as described in section 2.2.1. The impact of the different levels of compensation on suppliers is tested against several contract types, to assess the variability of the impact between retail market players.

Table 6 – Presentation of electricity retail markets in the Nordic countries

	Number of customers: total / household	Number of suppliers	Switching rate/ renegotiation rate	Most common contract
Finland (FI)	3.6/3.15 million	77	13.90%	Fixed flat price
Norway (NO)	3.3/2.7 million	155	21.60%	Dynamic price contract (75.9%)
Sweden (SE)	5.5/4.7 million	139	10%/24%	Open ended monthly variable (53.6%)
Denmark (DK)	3.41 (usage up to 100.000 kWh per year) million	50	8.30%	Fixed flat price (57%) contracts and variable price contracts (43%)

Source: CL analysis based on data from (NordREG, 2022).

Several approaches are used to estimate the level of electricity retail price. These approaches are defined by (i) a choice of market indices, (ii) weights of each market index, and (iii) a frequency of update. The price can also be differentiated between industrial and residential players, depending on the approach. The following four approaches are modelled in the study:

1. **Dynamic DA.** This approach corresponds to hourly spot dynamic contracts, where the billing is based on the actual hourly consumption data for each client. The electricity consumed in each hour is valued at the DA zonal spot price, for all types of clients.

2. **Monthly average DA.** This approach corresponds to hourly spot dynamic contracts, where the billing is not based on hourly consumption data, but on typical profiles applied to monthly volumes. This is particularly relevant for Sweden, where the roll-out of smart-meters has been historically slower than in the other Nordic countries, and where a significant share of consumers appear to be billed with this method. The price is updated on a monthly basis and calculated as the volume-weighted monthly average of day-ahead zonal prices. The consumption profile used to calculate the weighted average differs for residential and industrial consumers. For industrial consumers, a typical consumption profile is applied.[9] Moreover, as no publicly available data was available for residential consumers in the Nordics, the consumption profile applied corresponds to the non-baseload part of the

[9] Total demand from industrial consumers in France, data from RTE.

national load, assuming that the baseload part corresponds mainly to industry consumption.[10]

3. **DA & Futures.** This approach corresponds to the case of monthly flat prices based on a split of forward and spot sourcing. The retail price is calculated as the average between the monthly average DA price presented above and the average of Y+1 baseload forward products traded up to 1 year ahead.

4. **Actual prices.** To estimate the typical price level of yearly fixed contracts, publicly available historical prices are used and applied throughout the year. For residential consumers, historical 1-year fixed contract prices for larger households published by national public sources are used.[11] For industrial consumers, average electricity prices for industrial customers (consumption interval 20 to 70 GWh/year) published by Eurostat are used.

The average price for the approaches presented above is displayed in Figure 8.[12] The differences between the constructed retail prices (e.g. for 2020, c.50% difference for residential consumers between the DA & Futures method and the actual prices method for residential consumers) are mainly driven by the frequency of update and the underlying indices. For instance, by design DA monthly averages are more reactive to changes in market conditions, and therefore more volatile, compared with actual prices which have more inertia as they are typically based on forward products traded ahead of real time.

The relatively large differences between the estimated and the actual retail prices provide a view on the impact of different retail prices on the quantitative results.

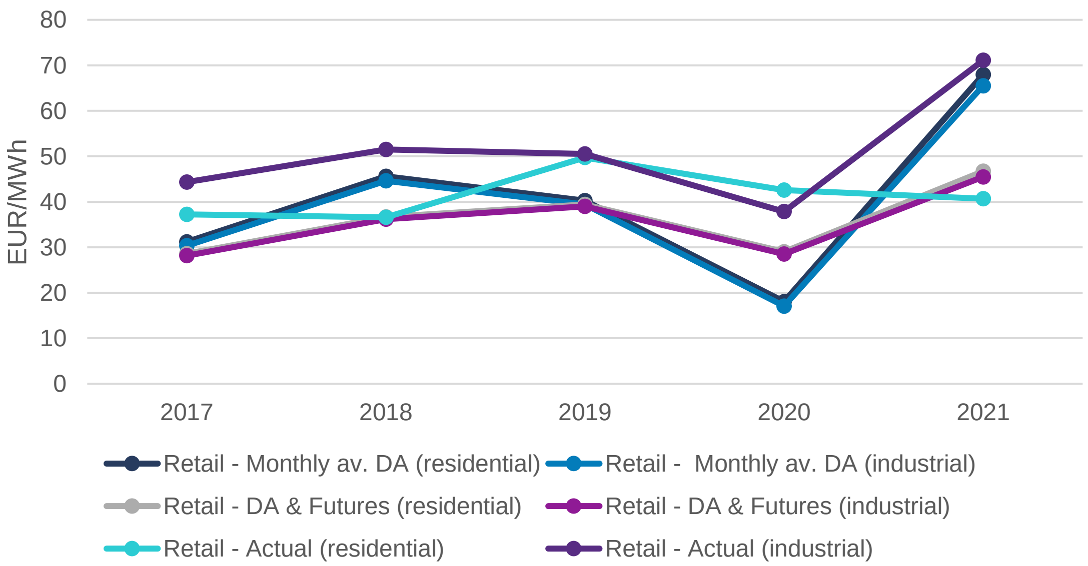


Figure 8 – Average across bidding zones of retail prices for each approach

Source: CL analysis based on data from Eurostat, ENTSO-E, and national statistical/regulatory offices.

[10] National load profile minus the minimum hourly load of the year.

[11] Distinction of household's consumption size (~30MWh) and contract (1-year fixed) where available (FI, SE, partially NO, not DK (representative 4MWh household).

[12] The dynamic DA approach is not shown on the graph as its yearly average is very much aligned with the yearly average of the Monthly average DA approach.

Baseline consumption

The baseline consumption corresponds to the typical consumption of a consumer in the absence of DSF activation, i.e. a counterfactual reference about what the supplier's allocated volume would be in the absence of the DSF activation. It can be split into two parts: (i) flexible consumption, i.e. the part of the consumption for which DSF can be activated, e.g. consumption from EVs or HPs, and (ii) non-flexible consumption. The flexible baseline consumption is calculated by applying the de-rating factors, defined in Table 5, to 1 MW.

In the absence of more precise publicly available data regarding the exact ratio between flexible and non-flexible consumption in the portfolio of suppliers in the Nordics, a yearly flat consumption of 1 MW is assumed for the non-flexible baseline consumption.

The actual share of non-flexible consumption is likely to be higher than the share of flexible consumption, at least in the short term, given the relatively low current share of consumers engaging with aggregators. The actual impact on suppliers, taking into account the entire portfolio of suppliers, is therefore likely to be lower than the figures presented in this study.

Moreover, the impact of the rebound effect, i.e. the fact that the change in consumer load during activation periods might be partly or fully compensated by a symmetrical change outside of the activation window, is qualitatively addressed in this study.[13]

2.2.3 Limitations of the methodology

Despite the best efforts to minimise limitations of this study, there are inevitable several ones present.

1. The participation of IA in each of the studied markets (DA, ID, balancing) is modelled separately, without taking into account any potential arbitrage strategy. However, in practice, IAs may maximise their profits by participating in various schemes depending on the expected revenues at a certain point in time compared to the others. Future work could explicitly study such arbitration strategies.

2. The analysis shows that IAs capture the highest revenues through the provision of ancillary services, assuming IAs are able to meet the technical requirements of the balancing reserves. Despite the fact that IAs work with portfolios of assets where the limitations of individual units to meet specific balancing reserve requirements can be diluted, the actual availability and potential of suitable assets may in practice be limited. Similarly, the impact of saturating flexibility offered for activation and reservation at their respective prices was not studied and would require a detailed market model.

3. A number of key assumptions had to be made to model DSF or to estimate retail prices. Although most of them are based on public sources or interviews, some assumptions had to be taken on expert judgement.

4. The rebound effect is not simulated in the quantitative assessment, and the robustness of the conclusions against this phenomenon needs to be qualitatively tested.

5. The modelling approach did not take into account uncertainty and perfect foresight on actual prices was assumed. Within our modelling framework and assumptions, the results may therefore be seen as upper bounds because with uncertainty market participants are prone to make errors.

[13] See section 3.3.

3 Analysis of the compensation approaches

In this section, we present the high-level findings of our quantitative analysis, and assess each level of compensation against each criterion.

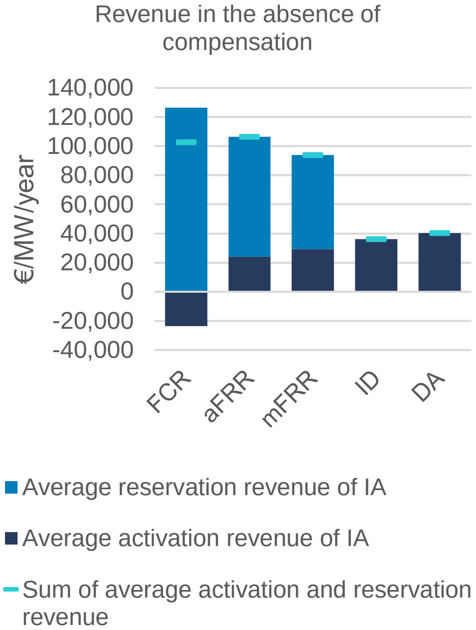
This section covers the following topics: impact on suppliers, impact on independent aggregators, impact on electricity consumers, efficiency distortions, impact on competition, and implementation issues.

3.1 Overview of quantitative results

The most profitable market segments for DSF are consistently and by far balancing reserves, due to the significant share of capacity remuneration in total revenues of IAs.

Based on our analysis, IAs capture the highest revenues through the provision of ancillary services, provided they can meet the technical requirements of the balancing reserves, with capacity remuneration making up the bulk of the revenues. Moreover, this is consistent for approaches with and without compensation, and independent of the compensation approach in place.

For example, Figure 9 shows that the income from balancing reserves for a portfolio of EVs is significantly higher than in the DA and ID markets in the absence of compensation, as well as with the compensation set at the hourly DA price.



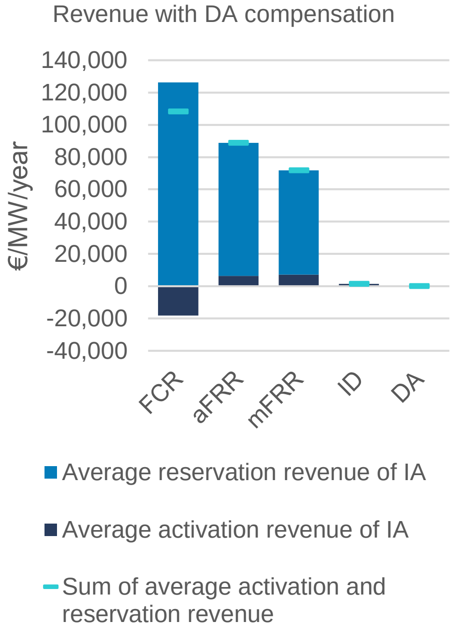


Figure 9 – Revenue of IA for a portfolio of EVs, in the absence of compensation and with DA compensation

Note: average of bidding zones and years 2017-2021, for a portfolio of EVs whose activation is driven by timing constraints. DK1 and DK2 are not included in the aFRR average reservation revenue due to limited available data in ENTSO-E dataset. DK2 is not included in the aFRR average activation revenue for the same reason. Swedish bidding zones are not included in the mFRR average reservation revenue calculation due the absence of mFRR capacity remuneration in Sweden.
Source: CL analysis based on data from ENTSO-E (FCR, FRR, DA) and Ei (ID).

The same conclusion is valid for all types of consumers able to provide balancing reserves. Moreover, due to stricter activation constraints (high opportunity cost), the share of energy revenues for industrial DSF tends to be even lower than for residential DSF. Balancing reserves appear as all the more profitable for IAs with a portfolio of industrial consumers compared with other revenue streams.

As one could expect, the presence of compensation reduces the value of energy revenues of IAs compared with a case without compensation (except for FCR, see section 3.2). Figure 9 illustrates this result in the case of the ToE compensation set at the DA price. The higher the compensation is, the higher the activation cost, and hence the lower the activation revenue and the lower the activation frequency.

Whereas the introduction of ToE compensation could hinder the profitability of DSF participation in pure energy markets like the DA and ID markets, IA revenues in balancing reserves remain significant despite ToE compensation thanks to capacity remuneration.

The total revenues of IAs in balancing reserves[14] are proportionally less affected by the introduction of ToE compensation and by the type of compensation implemented, as capacity revenues represent the bulk of ancillary services' revenues for IAs, and as capacity revenues are not impacted by the level of ToE compensation. The introduction of compensation for the ToE reduces the IAs' revenues participating in balancing reserves by 5% on average,[15] compared with 85% on average for the ID and the DA. Moreover, across the compensation approaches simulated in this study (the

[14] Which involve capacity payments, i.e. all Nordic reserves except mFRR in Sweden.

[15] Average for 2017-2021, all countries, and for 3 types of consumers (HPs and EVs with time-based activation constraints, and for industrial consumers with an opportunity cost of 300€/MWh).

no compensation case being excluded), the difference in revenue in balancing reserves between two compensation approaches corresponds to 2% of the mean total revenues in this reserve on average and in absolute terms. As a result, IA revenues remain above 80 k€/MW/year and DSF participation in these markets should therefore be profitable despite the compensation.

The conclusion for pure energy markets is the opposite as activation costs drive the revenues, which directly depend on activation, and hence the level of ToE compensation has a strong impact. The difference in revenue in energy markets between different compensation approaches corresponds to 88% of the mean total revenue in this energy market, on average and in absolute terms.

It is therefore unlikely that the choice of compensation may have a significant impact on the level of participation of IAs in balancing reserves, while on the contrary, the choice of the level of compensation is central to the participation of IAs in ID and DA markets.

When compensation is associated with the ToE, the impact on suppliers tends to be limited no matter the choice of the level of compensation

The quantitative assessment confirms that compensation would need to be associated with the ToE to avoid significant impact on suppliers. In the absence of compensation, IAs can source energy from suppliers at no cost when activating upward flexibility, and the quantitative assessment indicates that IAs tend to do so quite frequently as a result. For the participation of consumers in aFRR, mFRR, ID and DA, the impact on the revenues of suppliers ranges from -2% to -6% on average, compared with a situation without DSF activation.

On the contrary, implementing a compensation approach substantially limits the impact on suppliers, with only a -0.2% negative impact on average.[16] However, the impact on suppliers cannot be neglected in some situations, especially when suppliers bill consumers based on dynamic hourly pricing. Indeed, DSF tends to be activated upwards during price peaks. The increase in retail price suppliers would benefit from in such situation might not be reflected in the ToE compensation with flat retail approaches, hence involving a decrease in revenue for suppliers.

Point of attention: The activation opportunities of industrial players are strongly limited by their opportunity costs

The activation opportunities of IAs strongly depend on the activation constraints of their consumers. Assuming that the activation of consumers is driven by an opportunity cost, as in the case of industrial consumers, drastically reduces the activation opportunities of IAs, compared with the case of timing constraints as assumed for residential consumers.

The impact of activation constraints on activation opportunities is displayed in Figure 10. For instance, the revenues generated in the DA market by industrial consumers with an opportunity cost of 200€/MWh are on average c.2.5x higher than the revenues generated with an opportunity cost of 300€/MWh. Similarly, for residential DSF, the application of a (significant) minimum revenue to justify activation would strongly lower activation frequency and revenues. On average, the revenues generated in the DA market with an opportunity cost of 200€/MWh are 3-4x lower than when applying technical activation constraints.

[16] Average for 2017-2021, for all bidding zones, for 3 types of consumers (HPs and EVs with time-based activation constraints, and for industrial consumers with an opportunity cost of 300 €/MWh), for FCR, aFRR, mFRR, ID and DA, for all types of retail contracts.

In turn, the impact of industrial DSF activation on suppliers appears as negligeable. This result is consistent for all the compensation approaches modelled in this assessment, and across all retail price offers. This is even true in the absence of compensation: c. -0.5% decrease in revenue in the worst case.

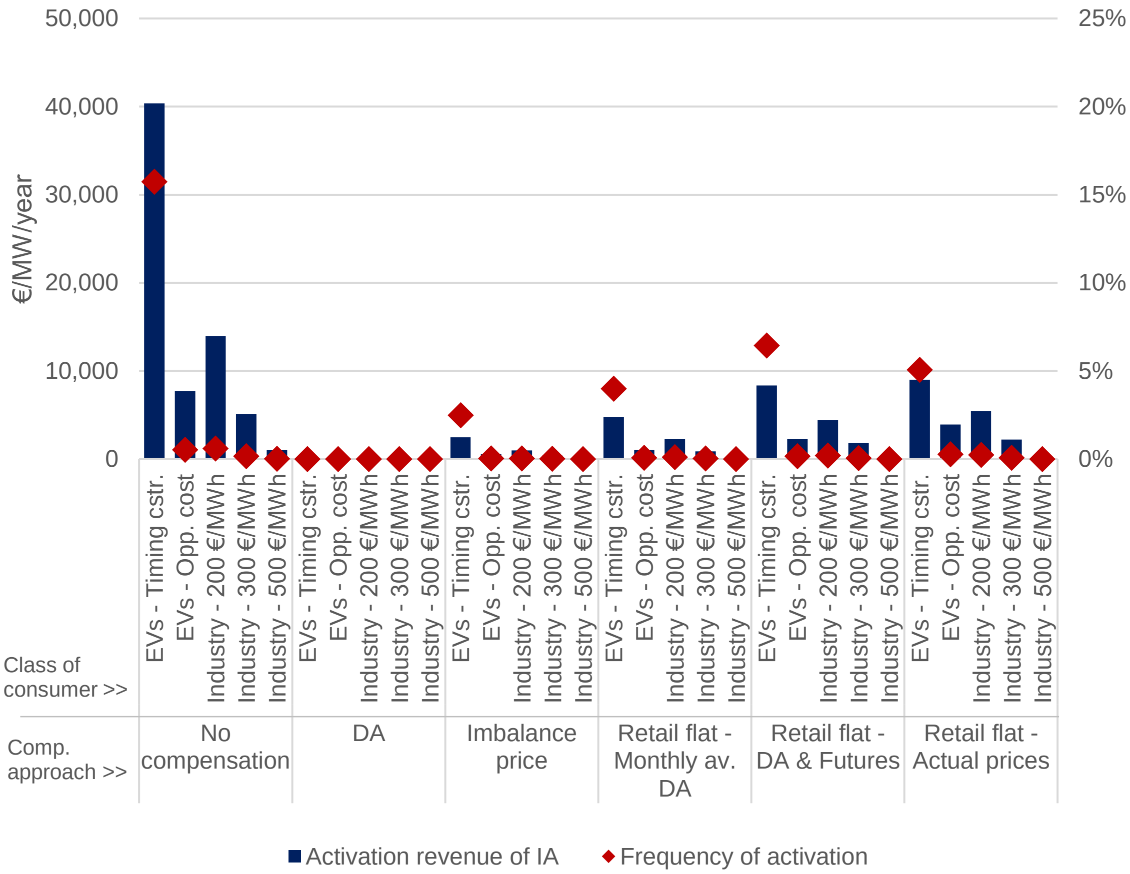


Figure 10 – Revenue of IA and frequency of activation in the DA market for different activation constraints on EVs and industrial consumers

Note: average revenue of IA and average frequency of activation in the DA market for all bidding zones, for 2017-2021, and for selected types of consumers, depending on the level of compensation.
Source: CL analysis based on data from ENTSO-E (FCR, FRR, DA) and Ei (ID).

3.2 Impact on Independent Aggregators

The revenue of IAs would be maximised if no compensation was associated with the ToE. This would in turn ensure that a significant volume of flexibility is offered, even in energy-only markets

Without any compensation associated with the ToE, IAs would be allowed to source energy from suppliers at no cost. IAs would be able to activate DSF more frequently (i.e. including in periods of lower prices – provided the activation is technically possible and not limited by other constraints) – and they would be able to capture a larger share of the benefits of DSF activations.

As a result, the activation revenue of IAs would be significant. For instance, in the DA market, Figure 11 indicates that the revenue of residential consumers could on average reach 40,000€/MW/year, which would allow the development of DSF in this market (literature[17] indicates that the minimum expected revenue of consumers to participate in energy markets typically starts around 15 k€/MW/year). Similar results are obtained for the participation of IAs in ID markets.

Moreover, the impact on revenues in the absence of compensation is in proportion higher for energy-only markets (DA, ID, mFRR in Sweden) than for balancing reserves, which include remuneration for capacity reservation. As mentioned in section 3.1, the introduction of ToE compensation reduces the IAs' revenues participating in balancing reserves by 5% on average, compared with 85% on average for the ID and the DA.

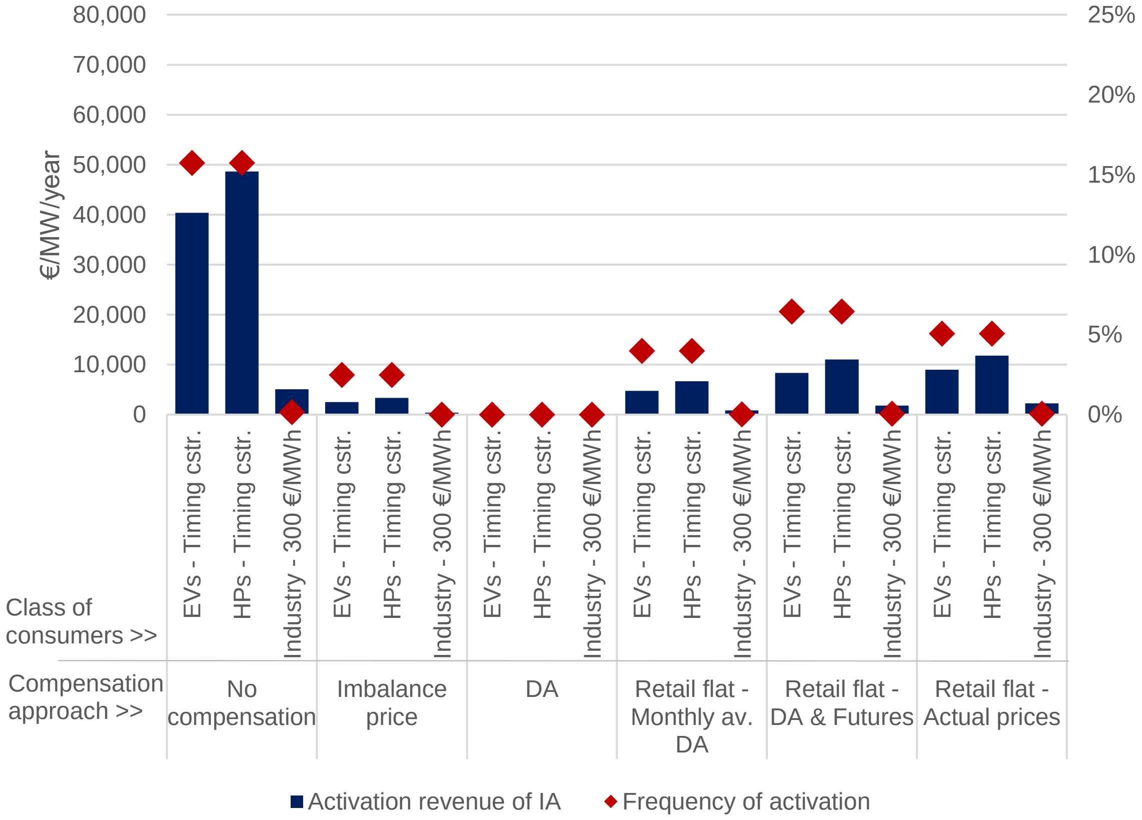


Figure 11 – Revenue of IA and frequency of activation for the participation in the DA market

Note: average revenue of IA and average frequency of activation in the DA market for all bidding zones and for 2017-2021, for HPs and EVs with time-based activation constraints, and for industrial consumers with an opportunity cost of 300€/MWh, depending on the level of compensation.
Source: CL analysis based on data from ENTSO-E (FCR, FRR, DA) and Ei (ID).

Setting the level of compensation at the DA, the ID or the imbalance price would prevent IAs from participating in some of these markets[18]

If the ToE is compensated at the DA price, selling DSF in the day-ahead market would lead to no benefit for IAs. Indeed, the IA would have to pay back to the supplier exactly the revenue it would earn selling DSF in the day-ahead market. This would in turn disincentivise IAs from participating

[17] Estimate based on (RTE, 2017).

[18] Setting the ToE at the DA price, the ID price, or at the imbalance price would prevent IAs from being activated in the DA market, the DA and the ID market, or the DA, the ID and the balancing reserves, respectively.

in the day-ahead market. This appears in Figure 11, with the activation revenue of each type of consumer in the DA market at zero when the ToE compensation is set at the hourly spot price.

Similarly, if the ToE is compensated at the ID price, selling DSF in the intraday market would lead to no/limited[19] benefit for IAs. Moreover, selling DSF in the DA would be risky: as the ID price is settled after the DA clearing, the compensation cost that IAs would need to pay when participating in the DA market would not be known when bidding in the DA market. This could involve potential losses, as further explained in Figure 12. Indeed, if the IA sells flexibility on the DA market at a given price, the advent of a system stress event after the DA closure could lead to an increase in the ID price compared with the DA. This would in turn lead to negative net revenues for the IA, as the ToE paid would be higher than the market revenues (in the case of upward flexibility). This would thus disincentivise IAs from participating in both the day-ahead and intraday market.

Figure 12 – Illustration – Risk of DSF participation in the DA market when compensation set at the ID price

Source: CL analysis.

Similarly, if the ToE is compensated at the imbalance price, activating DSF in the balancing market would lead to limited benefit for IAs and would be risky in the DA and ID market, with potential losses. This would create a barrier to energy market participation. For example, Figure 13 indicates that activation revenue in the mFRR market[20] would be very limited in this case, with very low frequencies of activation, below 2%/year. This is true even though we assume in the modelling an omniscient IA which bids in markets in an optimised way knowing the compensation price, while in practice in that case, it would know it afterwards.

[19] Given the continuous trading in intraday markets, there could be opportunities to trade at a price which would be slightly different from the ID price used as a reference in our analysis for a given hour, which is an hourly volume-weighted average price.

[20] Note that the Nordic countries are currently implementing and/or updating national mFRR capacity markets with the plan to have a common Nordic mFRR capacity market by Q4 2023 (see Nordic Balancing Model). The changes include, for example, shortening lead times of procurement (moving away from seasonal/weekly to hourly procured day-ahead), and procuring mFRR Down capacity in addition to standard mFRR Up. The expected impact of the emerging Nordic mFRR capacity market, which will be regional and more dynamic, is diversification and expansion of flexibility options. For example, shorter day-ahead procurement times are better adapted for distributed flexibility, such as EVs and HPs.

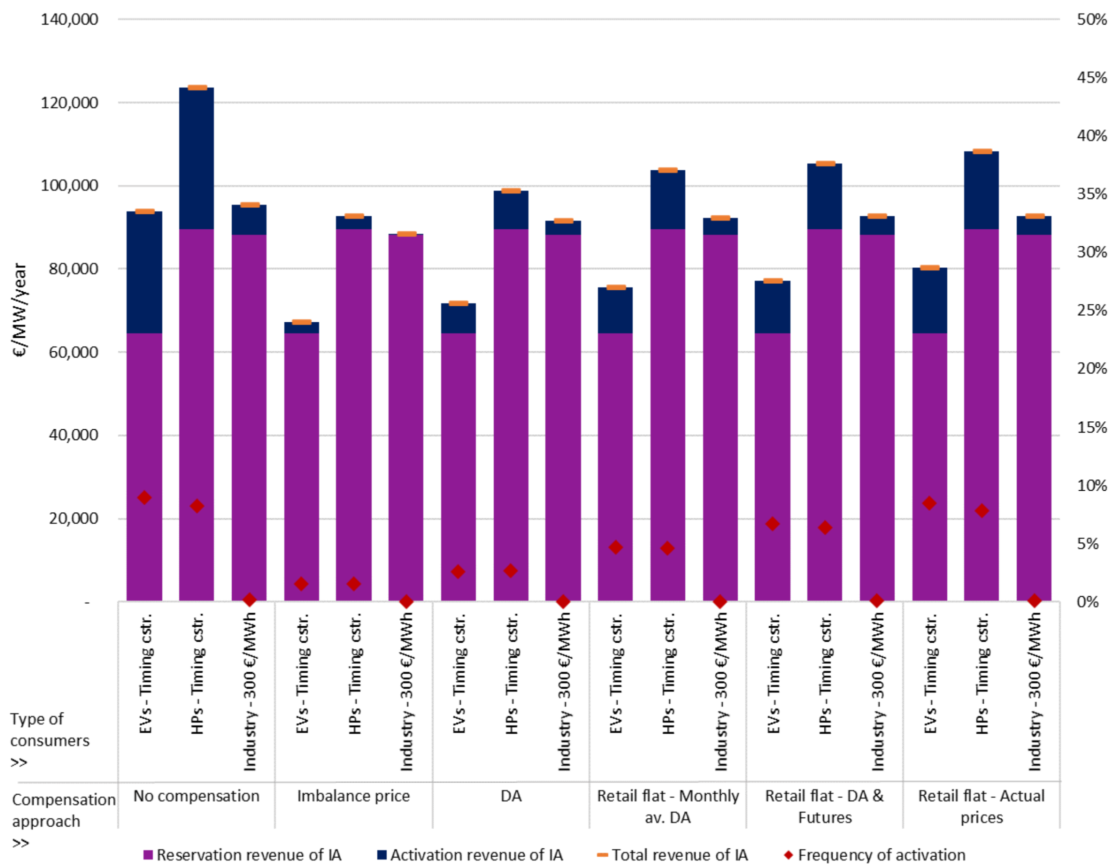


Figure 13 – Revenue of IA and frequency of activation for the participation in the mFRR market

Note: average of bidding zones and years 2017-2021, for HPs and EVs with time-based activation constraints, and for industrial consumers with an opportunity cost of 300€/MWh, depending on the level of compensation. Swedish bidding zones are not included in the mFRR average reservation revenue calculation due the absence of capacity remuneration in this reserve.
Source: CL analysis based on data from ENTSO-E (FCR, FRR, DA) and Ei (ID).

Moreover, IAs would be less competitive than other reserve providers when participating in reserve markets. This is because IAs would not get any revenues through activation and might not even cover some of their activation costs. They might therefore increase their reservation bids to take this into account.

Albeit challenging to perfectly estimate, a flat retail price approach might give the right signal for DSF activation to IAs.

In theory, a compensation of the ToE at the actual retail price would reflect the sourcing cost of electricity for IAs, and would therefore be an efficient signal for DSF activation.

Flat retail price approaches enable IAs to offer flexibility across multiple market places, including pure energy markets. When the level of compensation mimics retail prices that are either monthly flat (e.g. monthly average DA and DA & Futures approaches) or yearly flat (actual retail price approach), the level of compensation does not follow the price peaks in the energy market. Thus, during these price peaks, the level of compensation, and hence the cost of activation, tends to be lower than in more dynamic approaches (e.g. when the level of compensation is set at the DA or the imbalance price). This results in higher activation frequencies of DSF in energy markets, and in higher activation revenues.

For instance, in the mFRR reserve Figure 13 indicates that activation revenues with flat compensation approaches are on average 1.7 times higher than with the dynamic DA approach, and up to 8.8 times higher than with the imbalance price approach. Similar results are obtained on the DA, ID and aFRR market.

As discussed above in section 3.1, irrespective of the compensation scenario the balancing reserves correspond to the most profitable market segments due to the importance of capacity revenues. However, activation revenues of IAs on the DA could also be potentially high enough to incentivise DSF development on this market. For instance in 2022, activation revenues of IAs are estimated to be on average above 90 k€/MW/year, and up to 150 k€/MW/year, depending on the retail price approach used for compensation as displayed in Figure 14.

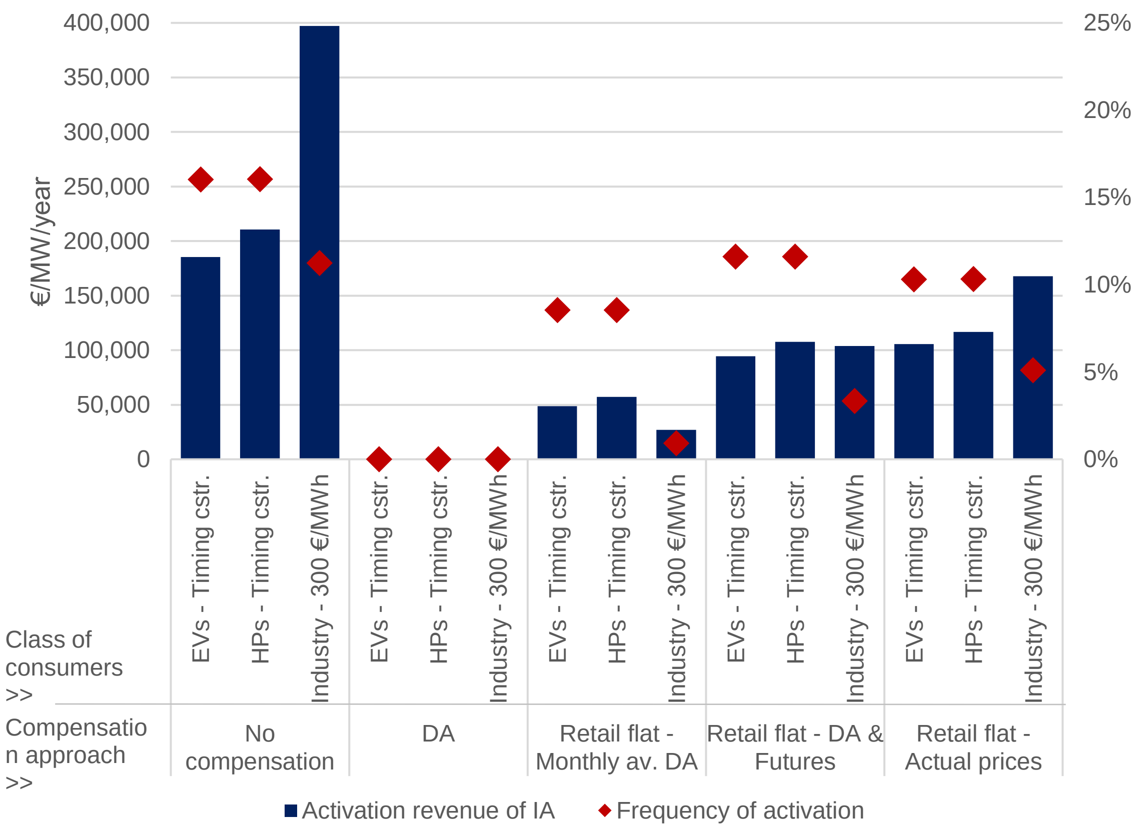


Figure 14 – Revenue of IA and frequency of activation for the participation in the DA market in 2022

Note: average revenue of IA and average frequency of activation in the DA market in 2022 for all bidding zones, for HPs and EVs with time-based activation constraints, and for industrial consumers with an opportunity cost of 300€/MWh, depending on the level of compensation. Source: CL analysis based on data from ENTSO-E (FCR, FRR, DA) and Ei (ID).

It is worth noting that the impact on total revenues of a flat retail approach for the level of compensation compared with an hourly dynamic approach is way higher in proportion in a pure energy market (DA, ID, mFRR in Sweden) than in balancing reserves, due to the predominance of capacity remuneration in the latter. For instance, in the DA market, revenues of IAs are on average 4 times higher with the actual retail price approach than with the imbalance price approach but only 1.1 times higher in the mFRR market.

Moreover, a ToE based on flat retail price provides predictability for both IAs and suppliers' BRPs. In turn, such predictable levels of compensation can contribute to reducing risks for market players, and hence to reducing price margins.

Conclusion regarding the impact on Independent Aggregators

Contrary to pure energy markets like the DA and ID, IA revenues from balancing reserves which include capacity remuneration are relatively unaffected by the type of ToE compensation implemented. As the balancing reserves are by far the most profitable for DSF, the choice of the compensation approach is unlikely to strongly impact its development and the overall volume of flexibility offered in electricity markets. IAs are expected to prefer balancing reserves over pure energy activation markets.

However, between the compensation approaches assessed, the flat retail price approaches seem to be the most favourable for IAs. This is because these maintain the opportunity of IAs to participate in energy-only markets where the attractiveness appears to be improving with increasing price volatility in recent years.

3.3 Impact on suppliers

In case no compensation is associated with the ToE, the negative impact on suppliers could be significant, except for FCR products

The approach with no compensation is the worst for suppliers when IAs activate upward flexibility in markets. On the contrary, it could be beneficial to suppliers when IAs activate downward flexibility.

In case of upward activation, a volume of energy is indeed transferred from suppliers to IAs through their BRPs, but suppliers do not receive any compensation for it. Suppliers therefore source energy for IAs but do not earn any revenues from it. On the other hand, IAs can value this volume of energy at no cost.

IAs activation costs are therefore lower with no compensation than under other compensation approaches, and they have more frequent opportunities to be activated upward. This has in turn a significant impact on suppliers. For instance, when IAs participate in the DA market in the absence of compensation, the financial impact of this approach for suppliers can be significant, with a 4% to 6%[21] change in revenue (depending on the retail price approach) compared with a situation with no DSF activation, as shown in Figure 15. This impact is consistent across market segments but tends to be higher for DA and ID than for aFRR and mFRR, where downward activation is also possible, leading to benefits to suppliers.

[21] Average of bidding zones, years, and types of participating consumers.

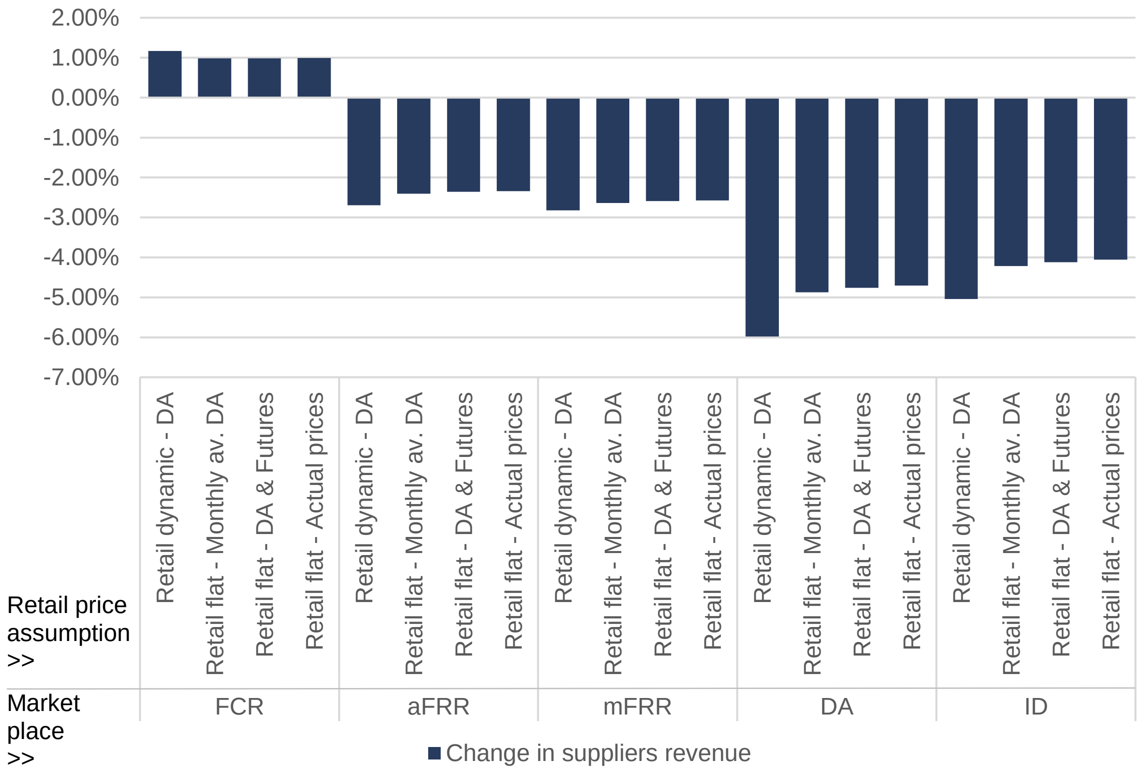


Figure 15 – Impact on supplier's revenues from participating consumers, without any compensation

Note: average of change in supplier's revenues in the absence of compensation, for all bidding zones, for 2017-2021 and for 3 types of consumers (HPs / EVs with time-based activation constraints, and industrial consumers with an opportunity cost of 300€/MWh), depending on the retail price estimation approach and on the market in which consumers are participating. DK2 is not included in the aFRR activation calculation due to limited available data in ENTSO-E dataset.
Source: CL analysis based on data from ENTSO-E (FCR, FRR, DA) and Ei (ID).

On the contrary, in case of downward activation, the impact is positive for suppliers. Indeed, during downward activation periods, suppliers' clients are consuming more, increasing suppliers' sales, while suppliers are sourcing this surplus of energy from IAs at no cost.

Figure 15 shows that the impact of DSF participation in FCR has a slightly positive impact on suppliers' revenue. Resources participating in FCR are constantly activated in both directions, but with a slight predominance of downward activation in the Nordic countries for the period considered (FCR is activated c.5% more downward than upward according to the data published by ENTSO-E). Overall, the impact on suppliers is thus positive, with the revenue of suppliers being subject to an increase of about 1% in these conditions, as shown in Figure 15.

Setting the level of compensation at the day-ahead price would minimize the impact on suppliers and would make DSF activation neutral to suppliers offering dynamic pricing

If the ToE is valued at the actual DA price during the activation period, suppliers which offer dynamic tariffs indexed on the hourly day-ahead price would be compensated correctly for the costs that they incur through the upward activation of DSF by IAs, which appears in Figure 16. Similarly, in case of downward activation, suppliers offering such dynamic tariffs would pay for the surplus of energy sourced from the IAs at the exact retail price, leading to no impact This is particularly interesting for Norway, in which the share of retail contracts based on hourly spot prices was estimated to be 76% by NordREG in 2022 (NordREG, 2022).

This approach may not perfectly compensate the impact of the ToE on suppliers which bill clients based on a diversified sourcing of energy, including forward prices. For instance in Finland or Denmark, a significant share of consumers still have fixed flat prices. Figure 16 shows that, on average over the considered period, the impact on suppliers is actually positive in most circumstances and, whether positive or negative, the average impact on suppliers across the variety of retail prices and market segments remains very limited, with an estimated average change lower than 0.3% in absolute terms for such suppliers.

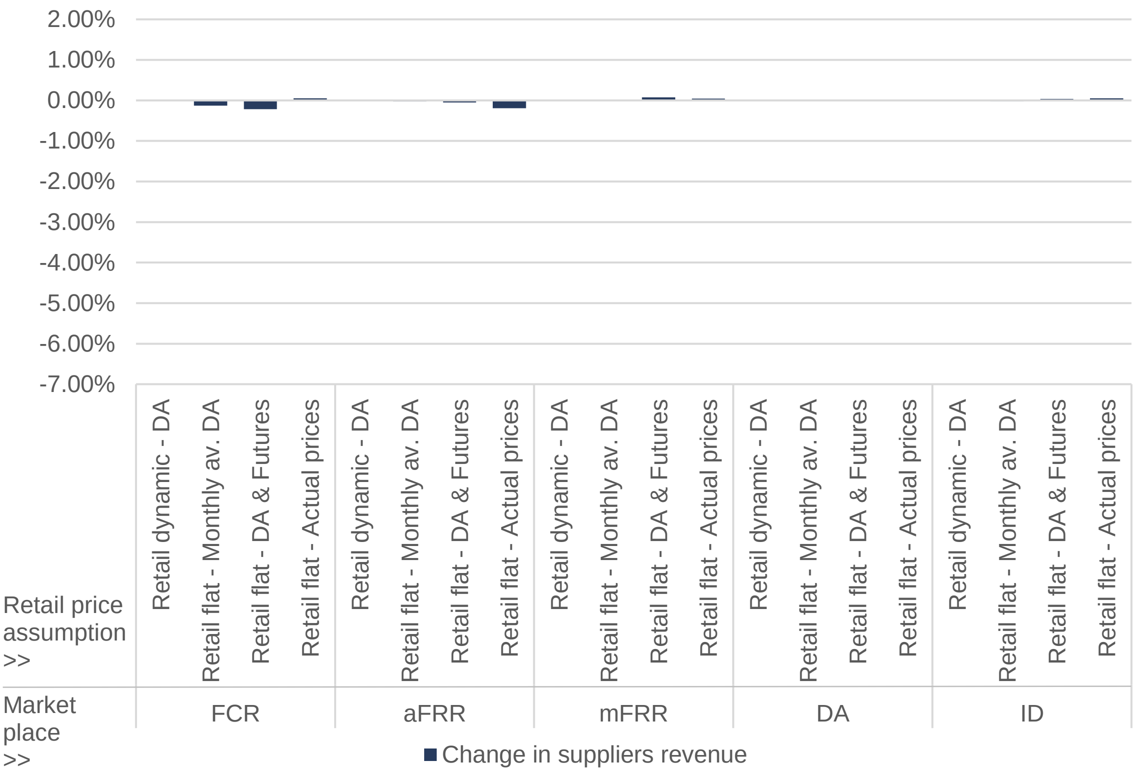


Figure 16 – Impact on supplier's revenues from participating consumers, with DA compensation

Note: average change in supplier's revenues with a ToE compensation set at the DA price, for all bidding zones, for 2017-2021 and for 3 types of consumers (HPs / EVs with time-based activation constraints, and industrial consumers with an opportunity cost of 300€/MWh), depending on the retail price estimation approach and on the market in which consumers are participating.
Source: CL analysis based on data from ENTSO-E (FCR, FRR, DA) and Ei (ID).

There can be occurrences in which the impact on suppliers for upward activation is negative. For instance, this can happen in periods of relatively low spot prices compared with higher past forward prices which were used to set the retail price. In such a case, the compensation paid to suppliers would be lower than their sourcing cost. This is for instance the case in 2020, which appears as the worst year for suppliers with this approach, albeit the negative impact remains very limited (less than 1% in absolute terms) (excluding participation of IAs in FCR).

On the contrary, the impact of upward activation can also be positive for such suppliers in periods of relatively high spot prices compared with past futures prices traded at lower prices. For instance, in 2021, revenues of suppliers after DSF activation can be more than 1% higher with DA price compensation, for consumers at the 'actual price' retail estimation, due to the high and likely unexpected increase in spot prices over the year.

The intraday price might not represent a good proxy for the cost of energy sourcing

As for the DA approach, the ID approach might imply potential positive or negative impacts on suppliers. This would be the case for suppliers which bill clients based on a diversified sourcing of energy, and which typically offer fixed flat prices, but also for suppliers using dynamic pricing. However, the impact would be limited. The ID approach is thus overall likely to be less adequate than the DA approach for suppliers, as the ID price might not be a good proxy for the cost of energy sourcing in any situation, even if less so than the no compensation approach.

In theory, setting the ToE at the imbalance price mimics a situation where the consumer has decided not to consume

Setting the ToE at the imbalance price mimics the situation where the consumer has decided not to consume (or to increase consumption) at a time when this was beneficial to the electricity system, creating an imbalance in the perimeter of the suppliers' BRP. This imbalance is then remunerated through the balancing mechanism.

Taking this perspective, the impact of this approach on suppliers would thus theoretically be neutral. Managing the uncertainty regarding the consumption of clients and being exposed to the balancing mechanism might be considered as part of the core business of suppliers.

However, given that the suppliers must maintain their supply despite their clients deciding not to consume (or to increase their consumption) and their BRP perimeters would be corrected accordingly, a different perspective could also be taken – namely comparing the imbalance price settlement with the loss of revenues due to lower sales to their client. Taking this perspective, Figure 17 shows the potential loss of revenues due to the difference between the imbalance settlement price and the retail prices. In practice, even though the imbalance settlement price does not reflect a typical supplier's sourcing strategy, the average impact on suppliers tends to be limited (less than 0.3% in absolute terms) and can either be positive or negative.

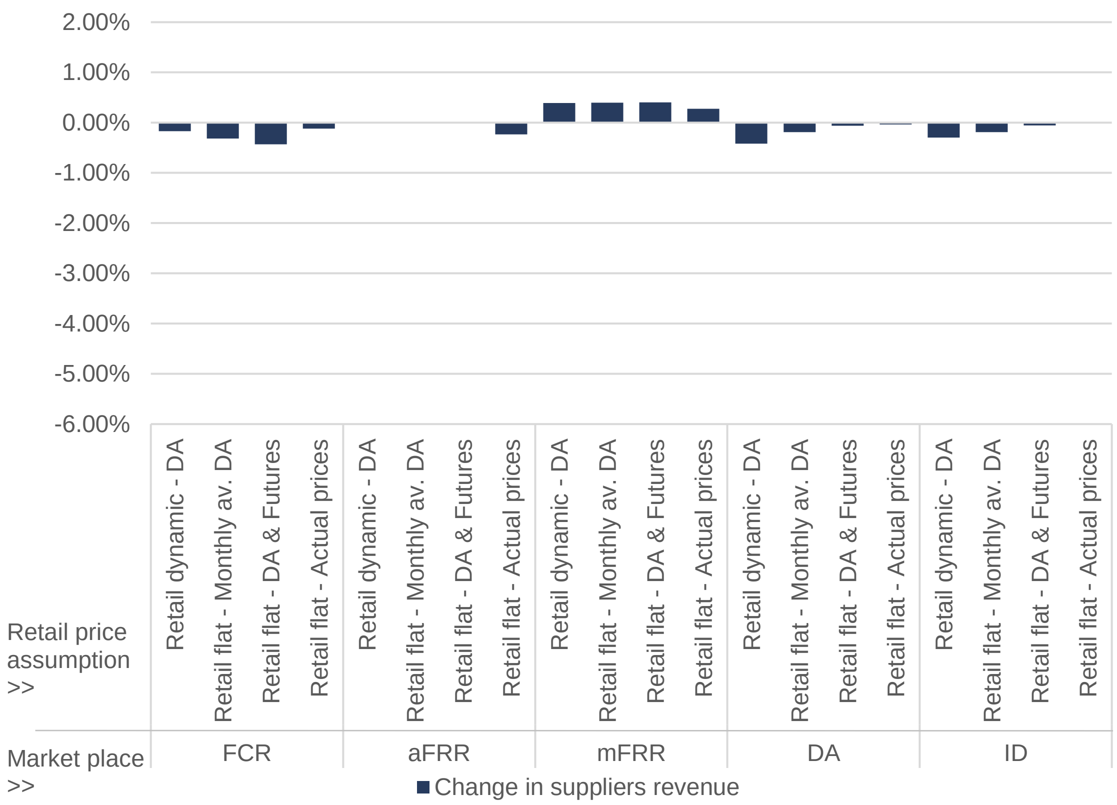


Figure 17 – Impact on supplier's revenues from participating consumers, with imbalance price compensation

Note: average change in supplier's revenues with a ToE compensation set at the imbalance price, for all bidding zones, for 2017-2021 and for 3 types of consumers (HPs / EVs with time-based activation constraints, and industrial consumers with an opportunity cost of 300€/MWh), depending on the retail price estimation approach and on the market in which consumers are participating. DK2 is not included in the aFRR activation calculation due to limited available data in ENTSO-E dataset.
Source: CL analysis based on data from ENTSO-E (FCR, FRR, DA) and Ei (ID).

When the ToE is compensated at a perfectly estimated retail price, the impact on suppliers is neutral

This approach theoretically ensures that suppliers receive compensation that corresponds exactly to the loss of revenue they incur through the activation of DSF. Figure 18 shows that when the compensation price approach matches the actual retail price of the activated consumers, the impact on suppliers' revenues is null.

However, implementing a regulated formula which perfectly estimates the retail price in every situation, considering all the different price structures, is challenging. The retail price levels and structures depend on many factors and on the supplier's and client's agreed contracts. Reflecting this properly in a central settlement model would require that a central entity would receive detailed information for each individual client participating at a given moment to a DSF activation. As a result, some simplifications are likely needed, which would cause deviations from the theoretical efficiency of the approach.

When the ToE is set at an approximation of the retail price, the impact between suppliers varies depending on the type of contracts offered. For instance, Figure 18 indicates that when IAs are active in the mFRR reserve with the compensation price set at an estimation of the retail price, the impact typically ranges from c. -2.5% to 0.2%. Moreover, Figure 18 also highlights that the less reactive the retail price reference used for the compensation is to spot price variations, the higher the impact on suppliers which offer dynamic pricing. This is even truer in a context of a price increase such as between 2020 and 2021: in case of upward activation, the level of compensation for the energy sourced doesn't match the expected billing price because the increase in DA prices is coming before the actual retail price.

Figure 18 also shows that the impact on suppliers may be positive, as the estimation of the retail price may be higher than the actual retail price applied to the activated consumers, especially when this estimation is based on the DA price. The positive impact on suppliers is nonetheless limited and close to zero. In such situations, the opportunities for IAs to activate DSF economically are strongly limited, therefore reducing the activation frequency and the impact on suppliers.

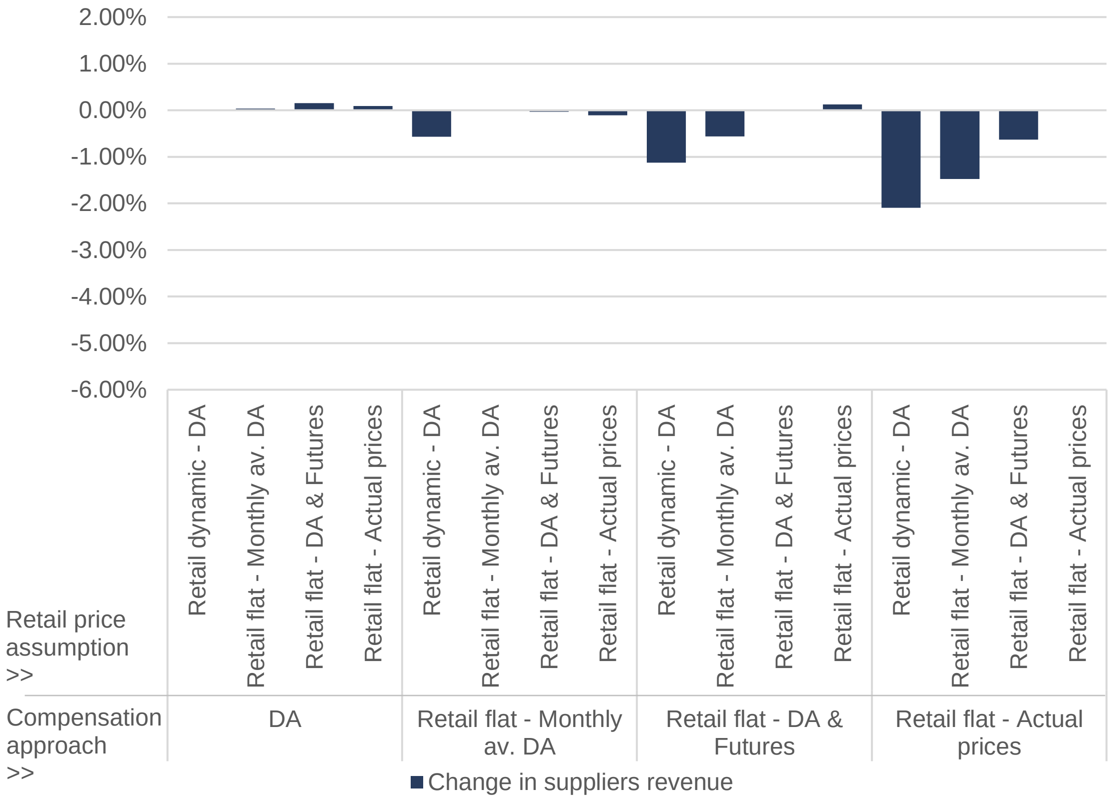


Figure 18 – Impact on supplier's revenues from consumers participating in the mFRR reserve, with ToE compensation set at the retail price, estimated with four different approaches.

Note: average change in supplier's revenues in the case of consumers participating in the mFRR reserve, for all bidding zones, for 2017-2021 and for three types of consumers (HPs / EVs with time-based activation constraints, and industrial consumers with an opportunity cost of 300€/MWh), depending on the retail price estimation approach and on the level of compensation chosen among the four retail price estimation methods.
Source: CL analysis based on data from ENTSO-E (FCR, FRR, DA) and Ei (ID).

Conclusion regarding the impact on suppliers

The impact assessment of these compensation approaches on the revenues of suppliers confirms that there is no optimal approach to set the ToE compensation for the participation of IAs in electricity markets, while at the same time totally neutralising the impact on suppliers. However, no matter which compensation approach is simulated, the impact on suppliers is overall limited, especially for industrials – except in the case of no compensation for residential.

Methods reflecting the day-ahead price, or the retail price seem to be the most relevant but could be either detrimental or favourable to suppliers depending on the actual retail price structure contracted with consumers. In any case, a typical client portfolio of suppliers includes several types of contracts: for a given compensation approach, the negative impact of a flexible consumer can be mitigated by the positive impact of the other.

Finally, the higher the share of consumers having dynamic pricing and hourly metered load for invoicing is, the more relevant the day-ahead price approach would be. This is particularly of interest in some of the Nordic countries where the penetration of dynamic pricing is very significant, e.g. in Norway.

Point of attention*: Suppliers might also be impacted outside of flexibility activation periods by the rebound effect, depending on the way the latter is considered in the compensation mechanism.*

The rebound effect corresponds to the fact that the change in consumer load during activation periods might be partly or fully compensated by a symmetrical change outside of the activation window. In such cases, the balancing position and the sourcing position of the supplier might as well be impacted outside of the activation period. Accounting for the rebound effect in the compensation mechanism is however challenging, as such a symmetrical change might happen at different time scales depending on the type of consumers – or not happen at all. For instance, for EVs charging during the night, the rebound effect might systematically happen overnight, while for industrial players, a change in production might reverberate over longer periods of time, e.g. weeks or months. Such a rebound effect is typically not considered in compensation mechanisms in Europe (DNV GL, 2022).

The rebound effect is not simulated in this quantitative assessment, and the robustness of the conclusions against this phenomenon needs to be qualitatively assessed. Putting practical considerations aside, at least two approaches can be envisioned regarding the rebound effect in the compensation mechanism: (i) the case of no perimeter correction nor compensation, and (ii) the case of a "rebound" ToE applied symmetrically after DSF activation.

In the former case, the perimeter of the supplier's BRP would not be corrected, and the supplier would therefore be in imbalance. In case of upward DSF activation, the rebound effect would correspond to an increase of demand. It would therefore generate a negative imbalance in the supplier's BRP, and therefore a cost – except in rare cases of negative prices. On the other hand, this increase in demand would result in higher energy sales – during the rebound period – from the supplier to its consumers. The impact on the supplier would therefore be the rebound volume multiplied by the difference between the retail price and the imbalance price. It could be either positive (if the imbalance price is lower than the retail price at that moment) or negative.

In the latter case, the perimeter of the supplier's BRP would be corrected. The impact on the supplier would then depend on the compensation price as it would be the rebound volume multiplied by the difference between the retail price and the compensation price. It could be either positive (if the compensation price is lower than the retail price at that moment) or negative, but as shown in the analysis, it is likely to be limited. This approach could increase the costs and the risks borne by the IAs, especially if the rebound is hardly predictable and occurs – after upward DSF activation – when the compensation price is lower than the imbalance price. On the contrary, it could present an opportunity for IAs if they are able to control the rebound and to place in profitable period (e.g. when the compensation price they receive for the rebound after upward DSF activation is higher than the day-ahead price).

3.4 Impact on electricity consumers

Without any compensation, consumers would benefit from a range of flexibility offers by IAs but suppliers may provide less interesting offers to flexible consumers

In the case of no compensation (or inadequate and insufficient compensation more generally), suppliers could hedge against the risk of loss of revenue linked to flexible consumers by proposing them offers which include a significant margin (e.g. on the energy or fixed fee component) compared with other traditional customers. While suppliers would not initially know about the DSF's impact on their revenues, they would be able to learn from the consumption behaviour of their DSF-active consumers and update the offered tariffs to existing and similar future customers accordingly.

The cost of energy supply in the no compensation case is thus likely to increase for flexible consumers. If the increase is significant compared with the total bill, i.e. higher than the expected revenue of DSF activation and reservation, this compensation approach might even disincentivise consumers from contracting with IAs to be involved in DSF activities.

In markets with low energy activation and high capacity-driven incentives, such as aFRR and mFRR (see e.g. Figure 13), the risk of increased costs of energy supply for flexible consumers is limited. Similarly, the risk of such cost pass-through to energy supply costs for industrial consumers is also limited because their energy activation is infrequent due to higher opportunity costs than those of households (EV/HP).

Setting the ToE at the DA, the ID or the imbalance price may prevent flexible consumers from valuing their flexibility in some of these markets

As described in section 3.2, if the ToE is set at the DA, the ID or at the imbalance price, IAs would not receive any revenue from (some of) these markets and would thus have no incentive to participate in them.

For example, if ToE were set at the imbalance price, IA would gain no benefit from energy activation in balancing markets which are settled at the imbalance price. Furthermore, participation in DA and ID markets with ToE based on imbalance prices would be risky for IA leading to likely losses, because the imbalance price is more volatile and known only after DA and ID price settlements. These factors would disincentivize IAs from offering consumers' flexibility in DA, ID and balancing (activation) markets. This would be potentially detrimental to flexible consumers, as they would lose opportunities to value their flexibility through IAs.

The only option they would have could be to contract with integrated suppliers which also offer aggregation / flexibility services – reducing competition and consequently the attractiveness of services offered to them.

The retail price approach reduces the opportunities for IAs to value flexibility compared with no compensation, but would limit impacts on suppliers

If the ToE was set at a perfectly estimated retail price, it would minimise the impact on suppliers, no matter what the structure of the retail price. This would therefore theoretically have no impact on flexibility offers from suppliers. As a result, consumers may be able to value their flexibility, including through IAs, while not being affected by an increase in their retail price due to the risks perceived by their suppliers.

From an IA's perspective, there is no incentive to choose consumers based on the compensation price unless it is individualised (see an overview of studied offers in section 2.2.2 - Retail offers from suppliers). However, if a consumer has dynamic pricing and responds to it, IAs may not have as much residual capacity to provide additional flexibility, limiting interest for IAs. This is also true but to a more limited extent for less responsive offers (e.g. DA monthly averages or a blend of DA monthly and yearly futures) when consumers would reduce (increase) consumption based on higher (lower) monthly price, leaving IAs with lower flexibility potential. In contrast, consumers on flat prices (e.g. a one-year fixed price contract) would not be price sensitive and would therefore offer more potential for IAs to induce and reward consumer flexibility.

Flexibility offers from suppliers may be negatively (positively) impacted in case of too low (too high) retail price estimation. This is illustrated for the year 2022 in Figure 19, which shows that higher price differences between retail price offers (and higher activation frequency in DA) may amplify the impact on suppliers' revenues. In the studied sample, the impact tends to be more negative when referring to flatter offers based on futures or the actual retail prices, since suppliers might not have fully anticipated a strong rise in DA prices and set the prices of their fixed offers – used for the ToE compensation – taking into account forward prices at a lower level than actual DA prices.

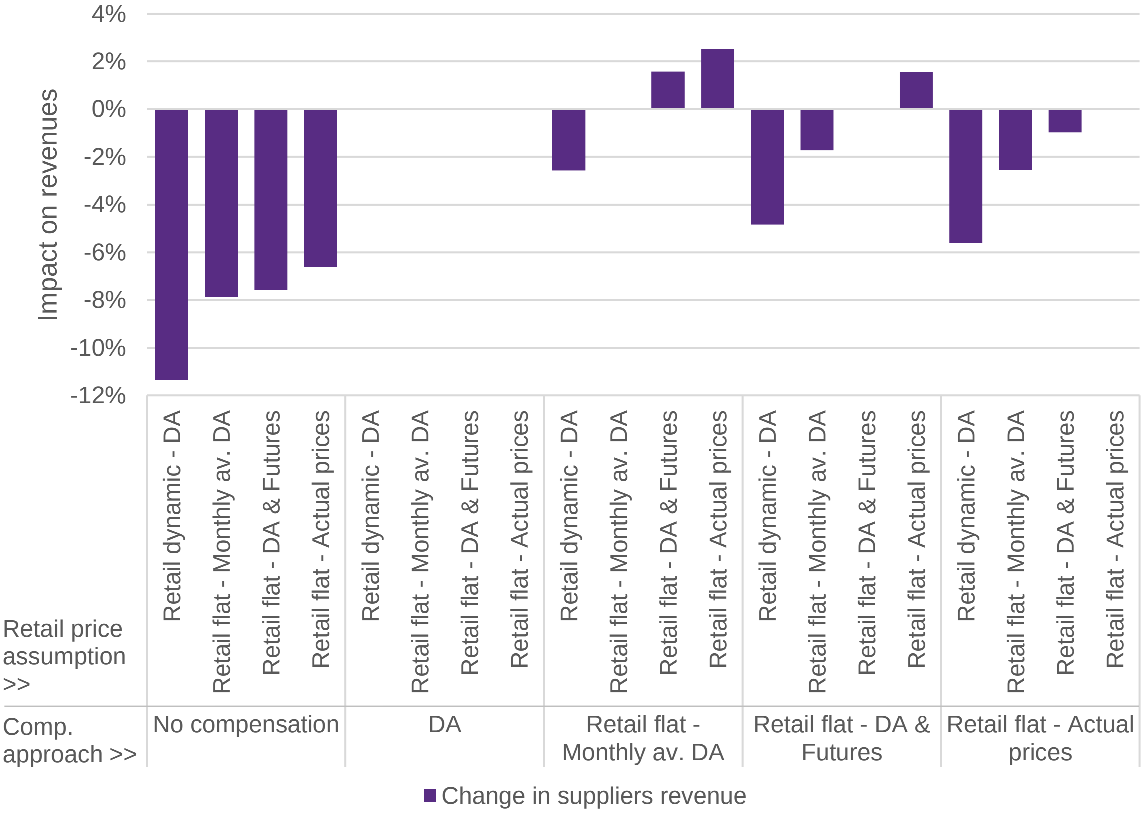


Figure 19 – Impact on suppliers' revenues from participating consumers due to activation in DA in 2022

Note: average change in suppliers' revenues in 2022, due to activation of consumers in the DA market, average for all bidding zones and for three types of consumers (HPs / EVs with time-based activation constraints, and industrial consumers with an opportunity cost of 300€/MWh), depending on the retail price estimation approach and on the level of compensation.
Source: CL analysis based on data from ENTSO-E (FCR, FRR, DA) and Ei (ID).

Conclusion regarding the impacts on consumers

The impacts of different compensation schemes for ToE on consumers are similar to those of IAs. For example, ToE valued at the DA, the ID or the imbalance price may prevent flexible consumers from valuing and therefore offering their flexibility in some of these markets.

However, in no compensation cases, consumers could be negatively affected via potentially increased energy costs which would be passed through onto them by suppliers. Suppliers could demand additional margins for the increased risks of lost revenues due to their customers' flexibility activation without adequate compensation.

3.5 Efficiency and distortions

The absence of compensation implies a risk of overactivation, as the activation cost does not account for the energy sourcing cost

With the no compensation approach, IAs would receive an incentive to activate DSF as soon as the market price is above its activation cost. It could thus activate DSF even when the system does not truly need it. This is because IAs would not bear the underlying cost of energy sourcing from suppliers, and might therefore be willing to sell this freely procured electricity back to the market below its actual cost.

For instance, considering the activation cost of 10€/MWh for EVs and not considering the activation constraints we define to overcome such issues, EVs' DSF would be activated as soon as the market prices would be higher than 10€/MWh, and would therefore be activated most of time, even when consumers would be ready to pay a higher price to charge their vehicles than other consumers buying in the market.

While this would have limited impact for industrial DSF given its high activation cost, it could multiply activation frequency of residential DSF by a factor of about three compared with scenarios with a compensation based on an estimation of retail prices.

Consequently, the absence of compensation could reduce the efficiency of DSF activation and create distortions in the market. DSF could be activated rather than other technologies with lower marginal cost in practice. Moreover, overactivation could dampen prices in the electricity market, directly impacting the profitability of other market participants.

However, when DSF is activated based on technical triggers, such as for FCR (or interruptibility schemes activated for large frequency deviations in other countries), and is not depending on IAs' bidding in the activation market, the absence of compensation may lead to no / only limited distortions or losses of efficiency in the activation. The compensation price then does not affect such activations because these are not price-based, so there are no activation distortions or impacts due to the ToE price.

DSF may not answer to price peaks in the DA / ID market, and/or the DSF would receive no incentive to participate in the balancing markets if the ToE is either set at the DA, the ID or at the imbalance price

As described in section 3.2, setting the level of compensation at the DA, the ID or the imbalance price would prevent IAs from participating in (some of) these markets, as participation would lead to no revenue. DSF would therefore not answer price spikes in these markets and their contribution to system services based on flexibility could be more limited. This could in turn increase price volatility and price spikes compared with a situation where ToE is set at the retail price.

Therefore, consumers with flat retail prices would have no incentives to provide their flexibility, neither through their retail price offer, nor through IAs.

Consumers with dynamic pricing indexed on the DA prices may have the incentive to provide their flexibility through their retail price offer to respond to the DA prices, but they would not have incentives to provide flexibility in the balancing timeframe, either through their retail price offer, or through IAs if the compensation is set at the imbalance price.

Perfect estimation of retail price for the ToE would theoretically lead to efficient activation of flexibility in all timeframes but significant misestimation would distort costs and volumes of flexibility offered

Setting the ToE at the retail price ensures that IAs can participate and respond to price spikes in all markets, as described in section 3.2.

However, distortions may arise in case of inadequate retail price estimation. For instance, implementing a compensation price formula which consistently overestimate suppliers' energy sourcing costs would lead to an under-activation of DSF compared with the optimum.

Conclusions on efficiency and distortions

Perfect estimation of retail prices for the ToE would theoretically lead to efficient activation of flexibility in all timeframes, avoiding distortions. However, the exercise is complex in practice and significant misestimation would distort costs and volumes of flexibility offered.

DSF may not answer to price peaks in the DA or ID market, and/or DSF would receive no incentive to participate in the balancing mechanism markets, if the ToE is either set at the DA, the ID or at the imbalance price, and if consumers are not subject to granular price signals through their retail price (e.g. dynamic pricing). Conversely, the absence of compensation implies a risk of overactivation, as the activation cost does not account for the energy sourcing cost.

3.6 Impact on competition

The absence of compensation would imply unfair competition between suppliers and IAs for the provision of flexibility services

In the absence of compensation for the ToE, IAs' sourcing costs are *de facto* being borne by the suppliers, which are also potential competitors both in electricity markets and towards consumers in valuing their flexibility. IAs would therefore have a clear competitive advantage for the provision of flexibility services, as part of their costs would be directly transferred to their competitors.

If the ToE is set at the DA, ID or imbalance price, suppliers would capture consumers willing to value their flexibility on these markets

With each of these compensation approaches, IAs would not be able to provide consumers with offers that allow them to value their flexibility on the (some of) these markets. Consumers willing to do so might therefore have no choice but contracting with suppliers rather than IAs to benefit from this type of flexibility offer.

This would therefore give a competitive advantage to suppliers against IAs.

However, for consumers that have a dynamic pricing retail offer, a ToE compensation at the DA price would not grant undue advantage either to suppliers or to IAs.

The retail price approach would create a level playing field between suppliers and IAs for the provision of flexibility services

If the ToE is set at the actual retail price, retailers would be adequately compensated for the volume of activated flexibility, and therefore, both categories of market players would bear similar activation costs.

Furthermore, both IAs and suppliers would be able to participate in every market, therefore accessing the same pool of potential customers.

As explained previously, biases may arise in case of inadequate retail price estimation. For instance, implementing a compensation price formula which consistently overestimates suppliers' energy sourcing costs would be detrimental to the IAs and favour the suppliers' offers. It could also be more detrimental/beneficial to suppliers offering certain types of offers compared with others.

However, the differences between compensation approaches reflecting retail prices on suppliers appear limited in our assessment, indicating that these biases may not have significant implications.

Finally, when most consumers have dynamic pricing retail offers, the most adapted proxy for the retail prices would converge towards the day-ahead price, guaranteeing an adequate level playing field.

Conclusion regarding the impact on competition

While the absence of compensation would be unfair towards suppliers, a ToE compensation based the DA, ID or imbalance price would limit opportunities for IAs and potentially create barriers to their participation in (some of) these markets.

A compensation at the retail price would in theory create a level playing field between suppliers and IAs for the provision of flexibility services. Biases could lead to a more favourable approach for IAs or for suppliers, or for certain suppliers depending on their main retail price offers. However, these biases may not have significant implications.

When most consumers have dynamic pricing retail offers, the most adapted proxy for the retail prices would converge towards the day-ahead price, guaranteeing an adequate level playing field.

3.7 Implementation issues

The no compensation approach is simple to implement, but could raise strong opposition from suppliers

The no compensation option is easy to implement in practice, especially insofar as it limits centrally organised financial flows. This could be a strong advantage, especially in situations where the energy activated is limited or where DSF is activated upward and downward relatively equally (e.g. FCR).

However, as mentioned in section 3.3 , the financial impact of this approach for suppliers might be significant, with a potential decrease in revenue of up to 6% (in absolute terms) compared with a situation with no DSF activation. That is why suppliers would likely strongly oppose such an approach and its implementation might be sensitive.

Setting the ToE at the DA price, ID price or imbalance price has the advantage of transparency and ease of implementation but could raise the opposition of IAs.

A ToE at the DA price, ID price or imbalance price would be easy to implement as the price reference would be clear and transparent, and would require no, or very limited, complicated calculations.

However, as described above in this report, the three approaches (based on DA, ID, or imbalance price) tend to be detrimental to IAs as they create a barrier for their activation in certain electricity markets. These approaches may therefore face strong opposition from IAs who could, for example, put forward arguments of unfair competition, if they are applied across all market segments.

This argument may though be of limited scope for the introduction of a ToE based on the DA price in countries where most consumers have retail offers with dynamic pricing based on the DA price. Indeed, the compensation to the suppliers would be adequate and consumers would have adequate incentives to value their flexibility, at least in the day-ahead market, through the price signal received in their retail price.

Designing a compensation formula which correctly estimates retail prices for every situation is complex

Although retail price is the approach that theoretically minimises adverse impacts on both IAs and suppliers and ensures a level playing field between market players, these positive effects depend on the accurate calibration of the retail price formula. Implementing a compensation approach based on estimated retail price brings several challenges.

Firstly, designing a formula that is satisfactory for all market participants – given the variety of suppliers' offers – can be complex, requiring extensive public consultation, debates on key design parameters – for instance the calculation methodology, the frequency of updates, or potentially regarding gathering of commercially sensitive data.

Secondly, to better approximate the retail price the level of compensation would ideally need to be differentiated between consumers, e.g. on the basis of their type of economic activity, their voltage level, and their type of supply offer. Implementing multiple layers of differentiation introduces greater complexity which may prove difficult to implement in practice, not only due to confidentiality reasons.

Thirdly, even if correctly calibrated against historical data during the consultation and with all market players, the formula would be unlikely to adapt to potential rapid or structural changes taking place in the retail or wholesale markets. To address this concern, the formula may need to be updated regularly on the basis of the shares of the main retail price approach.

Nonetheless, the quantitative analysis showed that the deviations around a correctly defined retail price estimation may not be so significant and therefore could be acceptable. In such a case, it should be possible to define a methodology which is not too complex to provide an adequate proxy of the average retail price. This could gradually adapt to market conditions taking into account the penetration of dynamic pricing, for instance. Once defined, the implementation of such a simplified methodology should not raise major concerns.

Conclusion regarding the implementation issues

The no compensation approach and, to a large extent, approaches based on DA, ID or imbalance prices do not raise major implementation issues except the risk of strong opposition by interested parties, either the IAs or the suppliers.

Conversely, compared with other approaches, compensation based on retail prices raises complex questions to address in order to define a good and robust methodology to estimate the adequate retail price. However, given the relatively limited impact of getting it wrong on IAs and suppliers, an acceptable methodology could be found. Once defined, the implementation of such a simplified methodology should not raise major concerns.

4 Conclusions

This section first provides an overview of the key findings based on the applied methodology. Then final conclusions and study limitations are presented.

4.1 Summary of findings

The quantitative results presented in section 3 indicate that **the most profitable market segments for DSF are consistently and by far the balancing reserves**, due to the significant share of capacity remuneration in the total revenues of IAs. This, however, strongly depends on the ability of DSF resources to meet the technical requirements to provide such balancing reserves.

Impact on IAs

Figure 1 also shows that, whereas **the introduction of ToE compensation could hinder the profitability of DSF participation in pure energy markets like the day-ahead (DA) and intraday (ID) markets**, **IA revenues in balancing reserves remain significant** despite ToE compensation thanks to capacity remuneration.

The quantitative analysis also indicates, on the basis of the assumptions defined with NordREG, that industrial DSF in any case has a lower frequency of activation due to high activation costs and may be less sensitive to the compensation level than residential DSF.

In the recent years though, the energy crisis has increased volatility and security of supply concerns in the market. Therefore, despite the introduction of ToE compensation, there could still be significant value for IAs in participating in day-ahead and intraday markets. However, compensation based on day-ahead, intraday or imbalance prices would act as a barrier to their participation as it reduces strongly the value IAs could capture in those markets and/or make their participation risky when the compensation price is not known in advance of this participation.

Impact on suppliers

If the compensation price is set at the actual retail price of the consumers, there is no impact on suppliers. Capturing the exact retail price would be, however, impossible or very difficult in practice.

The introduction of compensation associated with the ToE reduces the impact on suppliers – which can be positive or negative – no matter what the choice of the level of compensation (see Figure 3). The diversification of the suppliers' portfolio of customers can balance this impact further if they provide varied types of retail offers. Conversely, in case there is no compensation for the ToE, the negative impact on suppliers could be significant, up to -6% of their revenues.

Lastly, more substantial impact appears for consumers with dynamic pricing if the compensation is based on a flat retail price, while DA price compensation fully neutralises this impact. In general, DA price compensation limits the impact on suppliers as it reduces strongly the frequency of DSF activation.

Impact on electricity consumers

An inadequate compensation level could reduce possibilities for consumers to value their flexibility or could make their electricity bills more expensive.

On the one hand, compensation which is too low may prevent flexible consumers from benefitting from the most attractive retail prices. On the other hand, compensation which is too high would deter IAs from providing flexibility services to consumers.

Moreover, setting the compensation at the DA, the ID or the imbalance price would prevent certain consumers from valuing their flexibility in pure energy markets. Indeed, the compensation would in this case reflect the short-term volatility of prices, which would hinder the profitability of DSF activation, and in turn hinder the profitability of DSF participation in pure energy markets. Consumers with flat retail prices would therefore lose the opportunity to value their flexibility in such markets through IAs.

Efficiency and distortions

Perfect estimation of retail prices for the ToE would theoretically lead to efficient activation of flexibility in all timeframes. However, the exercise is complex in practice and significant misestimation would distort costs and volumes of flexibility offered.

Setting the ToE at the DA, the ID or the imbalance price would hinder the profitability of DSF activation, and IAs may therefore not answer to energy price peaks. Conversely, the absence of compensation implies a risk of overactivation, as the activation cost does not account for the energy sourcing cost.

Impact on competition

While the absence of compensation could have considerable negative impact on suppliers, ToE compensation based on the DA, ID or imbalance price would limit opportunities for IAs and potentially create barriers to their participation in (some of) these markets.

Compensation at the retail price would in theory create a level playing field between suppliers and IAs for the provision of flexibility services. Biases could lead to a more favourable approach for IAs or for suppliers, or for certain suppliers depending on their main retail price offers. However, these biases may not have significant implications.

When most consumers have dynamic pricing retail offers, the most adapted proxy for the retail prices would converge towards the day-ahead price, guaranteeing an adequate level playing field.

Implementation issues

The no compensation approach and, to a large extent, approaches based on DA, ID or imbalance prices do not raise major implementation issues but could face the risk of strong opposition by interested parties, either the IAs or the suppliers.

Conversely, compared with other approaches, **compensation based on retail prices raises complex questions** to address in order to define a good and robust methodology to estimate the adequate retail price. However, given the relatively limited impact of getting it wrong on IAs and suppliers, an acceptable methodology could be found. Once defined, the implementation of such a simplified methodology should not raise major difficulties.

Table 7 presents a visual summary of the evaluation of different compensation approaches against assessment criteria adapted and applied in this study.

Table 7 – Summary table of the main findings

Category	Criteria	No compensation	Day-ahead price	Intraday price	Imbalance price	Retail price
1. Impact on IAs	1.1. Impact on IA revenues					
	1.2. Impact on DSF development					
2. Impact on suppliers	2.1. Expected financial impact compared with status-quo					
	2.2. Variability given the range of retail offers					
3. Impact on electricity consumers	3.1. Impact on flexibility offers proposed to final consumers					
4. Efficiency /distortions	4.1. Impact on DSF activation					
	4.2. Impact on price formation					
5. Competition	5.1. Impact on competition between suppliers and IAs					
6. Implementation	6.1. Complexity of implementation					
	6.2. Replicability and contestability					

Note: the predominance of certain types of offers in a given market, e.g. dynamic pricing, could modify this analysis.
Source: CL analysis.

4.2 Conclusions

Compensation reflecting retail prices would be the most suitable approach, but the estimation of retail prices is complex and subject to errors.

Compensation based on day-ahead prices could reflect adequately retail prices for a large share of consumers in the Nordic countries and therefore **be a relevant option to consider, especially in countries where dynamic pricing** based on day-ahead prices is widespread amongst consumers or for most industrial consumers.

However, if applied **in situations where most consumers would have non-variable retail prices** (or would not be hourly metered), **using the day-ahead prices could act as a barrier to the participation of DSF** in pure energy markets such as the DA or the ID. Consumers would have no incentives to value their flexibility in such markets, neither through retail price signals, nor through IAs. In such scenarios, a compensation price based on a blend of day-ahead prices and flat retail price estimates, taking into account the actual proportion of dynamic pricing penetration, could be a more adapted solution. As regards balancing markets on the other hand, given the high proportion of capacity remuneration, the negative impact of using the day-ahead prices for the compensation on IA revenues would likely be limited.

Glossary

aFRR Automatic frequency restoration reserves

AS Ancillary services

BRP Balance responsible party

DA Day-ahead

DSF Demand-side flexibility

FCR Frequency restoration reserves

EV Electric vehicle

HP Heat pump

IA Independent aggregator

ID Intraday

NEMO Nominated electricity market operator

mFRR Manual frequency restoration reserves

ToE Transfer of Energy

ToU Time of Use

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A Appendix – Data sources

Table 8 – Overview of data sources used in the analysis

Market	Main source	Detail
Day-ahead	• ENTSO-E Transparency Platform	• Hourly day-ahead prices by bidding zone (12.1.D)
Intraday	• SKM syspower	• Data covers the Nord pool intraday market • Hourly volume weighted average prices by bidding zone
Balancing	• ENTSO-E Transparency Platform	Volumes (hourly by bidding zone): • Activated Balancing Energy (17.1.E) • Amount of Balancing Reserves Under Contract (17.1.B) Prices (hourly by bidding zone): • Prices of Activated Balancing Energy (17.1.F) • Prices of Procured Balancing Reserves (17.1.C) • Imbalance Prices (17.1.G)
Futures	• EnergyMarketPrice	• Annual futures (Y+1) system price baseload traded up to one year ahead (front year)
Retail price	Actual residential retail prices • National statistical offices • National energy agencies Residential consumption profile • ENTSO-E Transparency Platform Actual industrial retail prices • Eurostat Industrial consumption profile • Open Data Energy Networks (ODRÉ) platform	Actual residential retail prices • Annual average electricity prices (excluding taxes and levies) of household's consumption size (~30MWh) and contract (1-year fixed) where available (FI and SE available, NO partially, DK based on representative 4MWh household). Residential profile • Non-baseload part of the national load (national load profile minus the minimum hourly load of the year) Actual industrial retail prices • Annual average electricity prices (excluding taxes and levies) for industrial customers in the consumption category between 20 to 70 GWh/year (NRG_PC_204) Industrial profile (monthly weighted average) • Monthly average of the provisional hourly consumption profiles in the French transmission network all industrial sectors and voltage levels.

B Appendix – Presentation of detailed results

This appendix presents the detailed findings of the quantitative analysis. It includes a comparison of the results over the modelled years and bidding zones, as well as specific analyses for each country.

B.1 Detailed results – Comparison between years

The level of remuneration varies greatly over the years studied, as described in Figure 20. In particular, capturable revenues rise sharply in 2021, in line with the surge in electricity prices. This impact is stronger for aFRR and mFRR. The average capacity revenues for aFRR and mFRR in 2021 are indeed significant, and strongly impacted by capacity price peaks in specific periods in balancing reserves.

Compared with aFRR and mFRR, the impact of price peaks in 2021 is relatively less important on FCR revenues. However, FCR consistently provides high revenues for IAs in more normal years.

The impact of the rise of energy price peaks also appears in the trend of revenues in the DA and ID markets in Figure 20 (no compensation). In the absence of compensation, IA revenues on the DA market in 2021 are more than double those of 2017-2020.

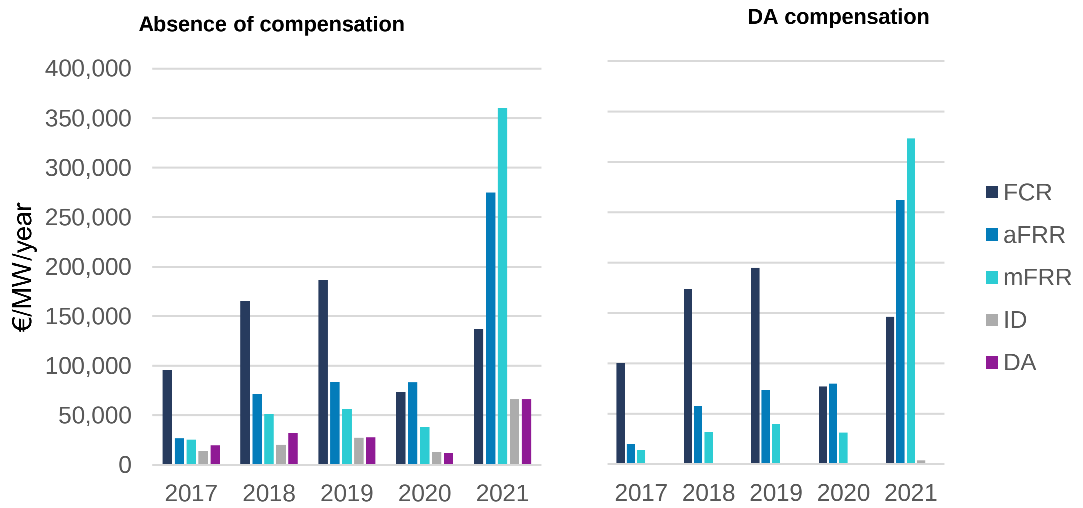

Figure 20 – Total revenue of IA in the absence of compensation and with DA compensation across years

Note: average of all bidding zones, for HPs and EVs with time-based activation constraints, and for industrial consumers with an opportunity cost of 300€/MWh. Regarding total revenue in aFRR, DK is excluded from calculations due to limited available data in ENTSO-E dataset.
Source: CL analysis based on data from ENTSO-E (FCR, FRR, DA) and Ei (ID).

B.2 Detailed results – Comparison between countries

B.2.1 Overview of cross-country comparison

In most countries, FCR and/or aFRR are the most lucrative markets for IAs, due to the significant share of capacity remuneration in the total revenues of IAs. This seems to be the case, for instance, in Sweden, Finland, and Denmark.

Norway is a special case: the level of capacity remuneration in FCR, aFRR and mFRR reserves tends to be lower in Norway than in the other countries. This appears clearly in Figure 21 for NO3 and NO4. Moreover, although the average revenues from mFRR participation in NO1, NO2 and NO5 are relatively high, these average values are driven up by very high reservation prices in December and November 2021 for weekly capacity products (up to 1000€/MW/h).

Moreover, variations can be observed between the bidding zones of a given country. In Norway and Sweden for instance, the level of remuneration in pure energy markets in northern bidding zones (respectively NO3, NO4, and SE1, SE2) is lower than in southern bidding zones (respectively NO1, NO2, NO5, and SE3, SE4).

Figure 21 – Total revenue of IA in the absence of compensation and with DA compensation across bidding zones

Note: average revenue of IA for 2017-2021, for HPs and EVs with time-based activation constraints, and for industrial consumers with an opportunity cost of 300€/MWh. This graph shows limited revenue in Denmark in the aFRR reserve. This is due to the absence in ENTSO-E dataset of aFRR capacity price data in DK1 and DK2, and of aFRR activation data in DK2.
Source: CL analysis based on data from ENTSO-E (FCR, FRR, DA) and Ei (ID).

B.2.2 Detailed results – Sweden

Compared with the other countries included in this study, Sweden is characterised by (i) relatively high capacity prices in the FCR and aFRR reserves and (ii) by an absence of capacity remuneration in the mFRR reserve, as shown in Figure 21 and Figure 22. Moreover, price levels in pure energy markets tend to be higher in southern bidding zones (SE3 and SE4) than in northern bidding zones (SE1 and SE2). For instance, between 2017 and 2021, DA prices in SE3 and SE4 are on average 23% higher than in SE1 and SE2.

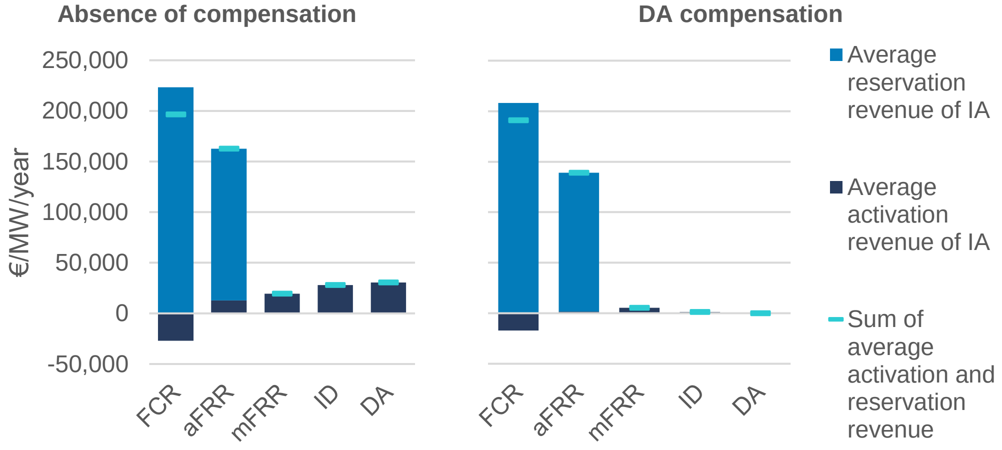

Figure 22 – Revenue of IA in the absence of compensation and with DA compensation in Sweden

Note: average revenue of IA for all Swedish bidding zones in and for years 2017-2021, for HPs and EVs with time-based activation constraints, and for industrial consumers with an opportunity cost of 300€/MWh.
Source: CL analysis based on data from ENTSO-E (FCR, FRR, DA) and Ei (ID).

Regarding the impact of compensation approaches on IAs, the activation revenues of the latter are in line with the average of other bidding zones. In FCR and aFRR, as on average capacity prices appear to be higher than in other countries, the choice of compensation has an even lower impact in proportion, as the bulk of revenues would stem from capacity payments. However, in the absence of capacity remuneration in mFRR, the choice of compensation approach is crucial to enable the participation of DSF in this market segment. In particular, an hourly dynamic compensation approach (e.g. compensation set at the DA, the ID or the imbalance) would prevent participation of DSF in this market, as highlighted in Figure 25.

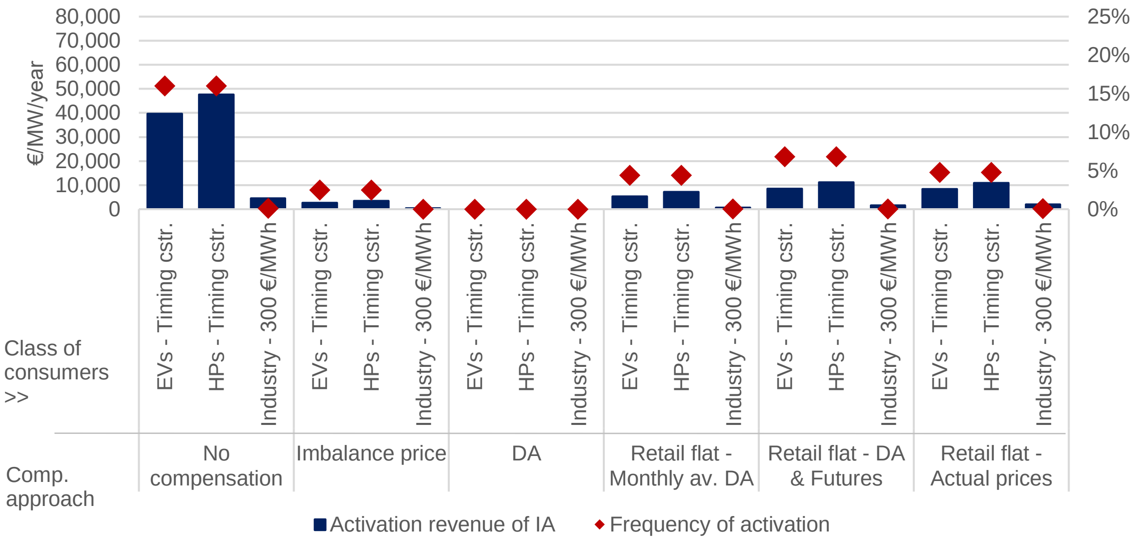

Figure 23 – Revenue of IA and frequency of activation for the participation in the DA market in Sweden

Note: average revenue of IA and average frequency of activation in the DA market for all bidding zones and for 2017-2021, for HPs and EVs with time-based activation constraints, and for industrial consumers with an opportunity cost of 300€/MWh, depending on the level of compensation.
Source: CL analysis based on data from ENTSO-E (FCR, FRR, DA) and Ei (ID).

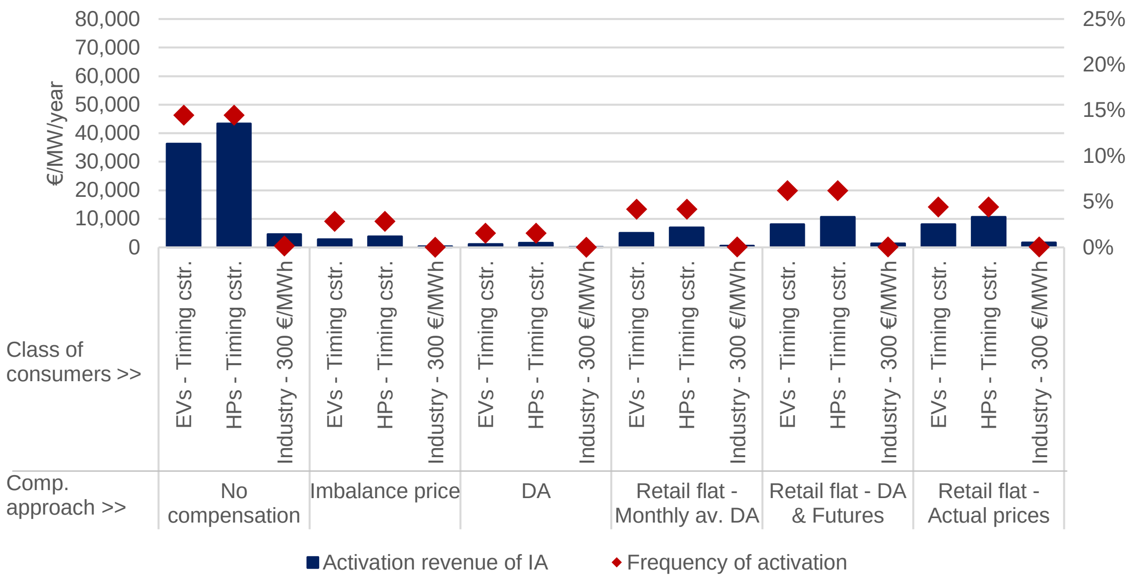

Figure 24 - Revenue of IA and frequency of activation for the participation in the ID market in Sweden

Note: average revenue of IA and average frequency of activation in the DA market for all bidding zones and for 2017-2021, for HPs and EVs with time-based activation constraints, and for industrial consumers with an opportunity cost of 300€/MWh, depending on the level of compensation.
Source: CL analysis based on data from ENTSO-E (FCR, FRR, DA) and Ei (ID).

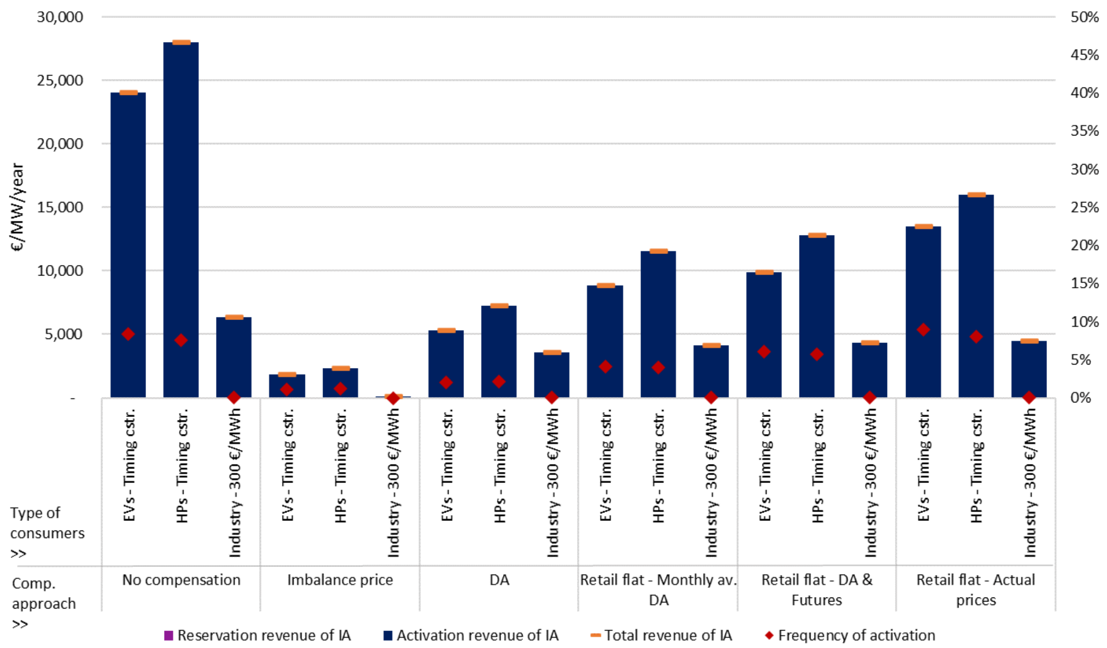

Figure 25 – Revenue of IA and frequency of activation for the participation in the mFRR market in Sweden

Note: average revenue of IA and average frequency of activation in the mFRR market in Sweden and for 2017-2021, for HPs and EVs with time-based activation constraints, and for industrial consumers with an opportunity cost of 300€/MWh, depending on the level of compensation.
Source: CL analysis based on data from ENTSO-E (FCR, FRR, DA) and Ei (ID).

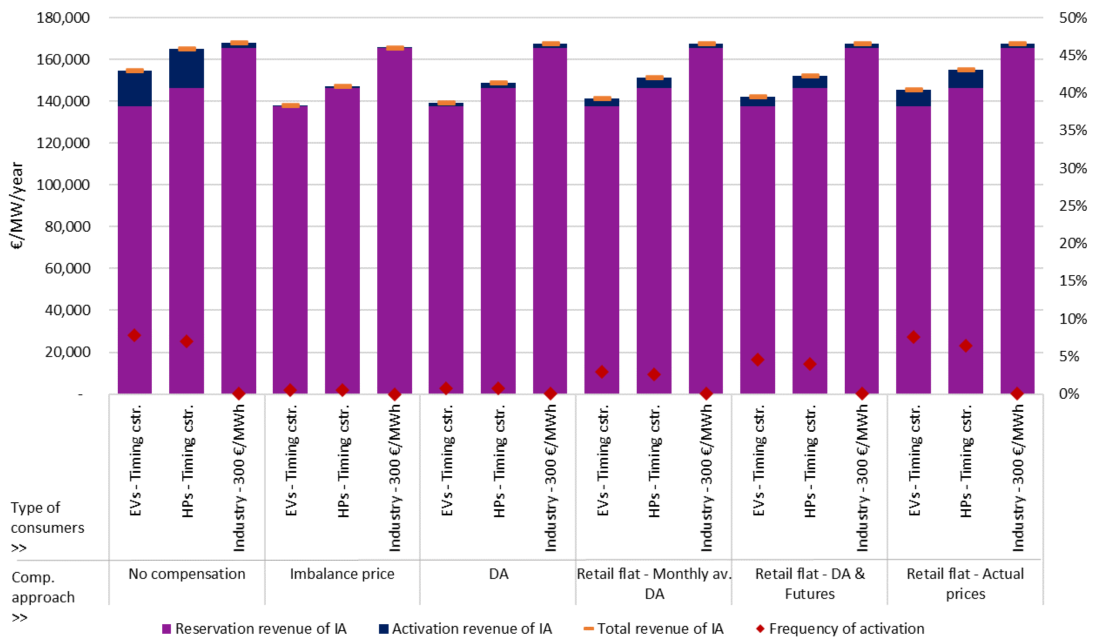

Figure 26 – Revenue of IA and frequency of activation for the participation in the aFRR market in Sweden

Note: average revenue of IA and average frequency of activation in the aFRR market for all Swedish bidding zones and for 2017-2021, for HPs and EVs with time-based activation constraints, and for industrial consumers with an opportunity cost of 300€/MWh, depending on the level of compensation. For aFRR capacity prices, data published by the TSO at SE level are used for each bidding zone.
Source: CL analysis based on data from ENTSO-E (FCR, FRR, DA) and Ei (ID).

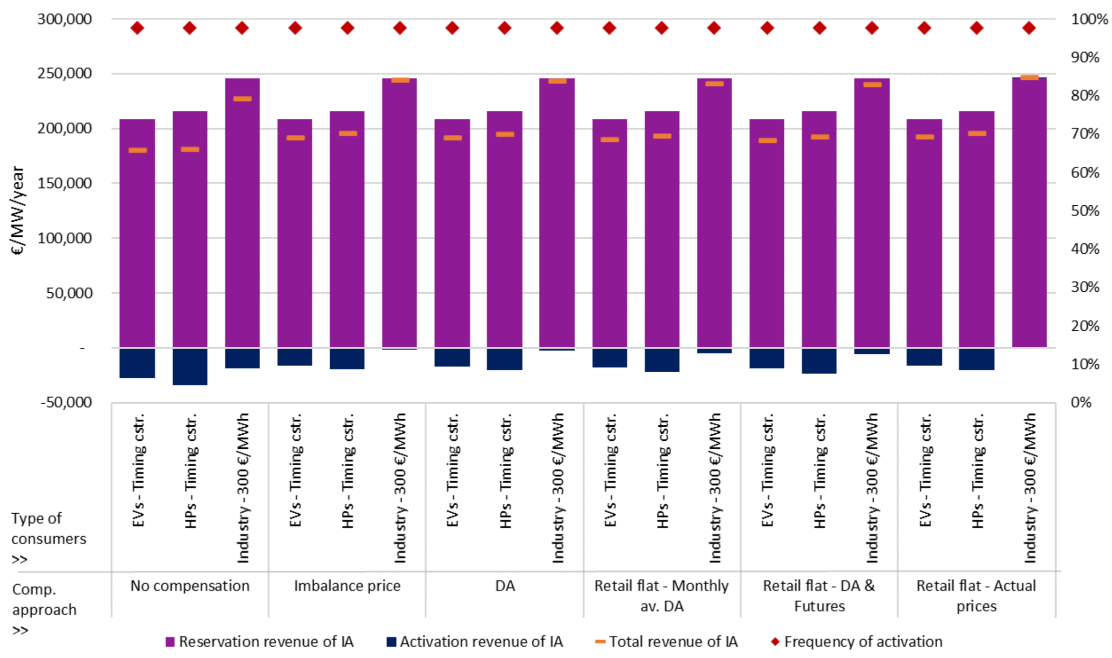

Figure 27 – Revenue of IA and frequency of activation for the participation in the FCR market in Sweden

Note: average revenue of IA and average frequency of activation in the FCR market for all Swedish bidding zones and for 2017-2021, for HPs and EVs with time-based activation constraints, and for industrial consumers with an opportunity cost of 300€/MWh, depending on the level of compensation.
Source: CL analysis based on data from ENTSO-E (FCR, FRR, DA) and Ei (ID).

The impact on suppliers is, however, in line with values from other countries, with an average negative impact on revenues typically below 2% in the presence of compensation, as shown in Figure 28 and Figure 29.

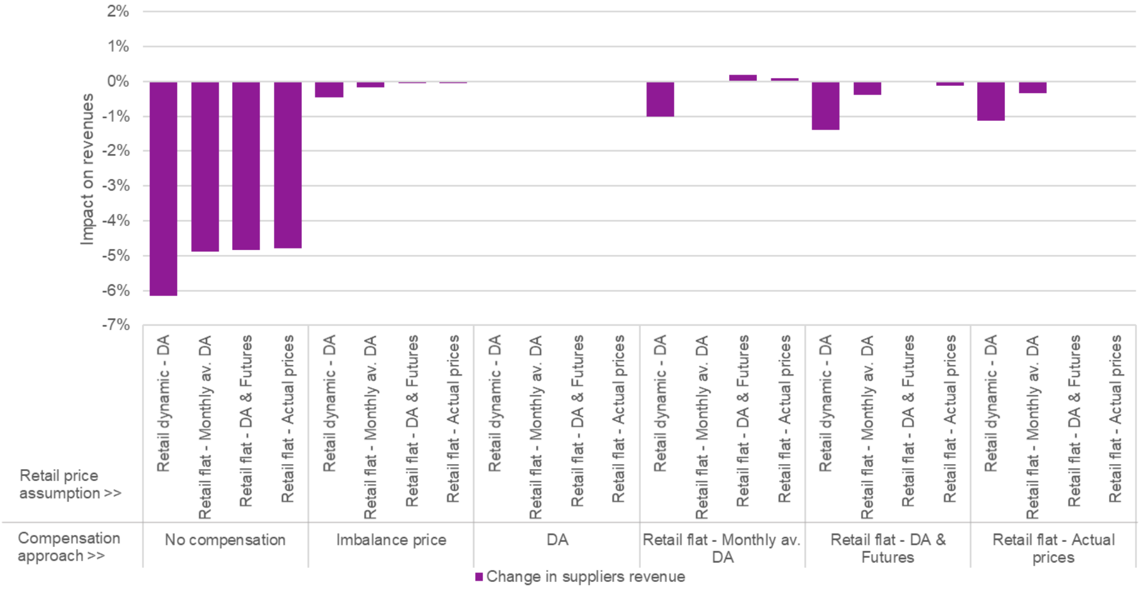

Figure 28 – Impact on suppliers' revenues from participating consumers due to activation in DA in Sweden

Note: average change in supplier's revenues for all Swedish bidding zones, for 2017-2021 and for 3 types of consumers (HPs / EVs with time-based activation constraints, and industrial consumers with an opportunity cost of 300€/MWh), depending on the retail price estimation approach and on the level of compensation.
Source: CL analysis based on data from ENTSO-E (FCR, FRR, DA) and Ei (ID).

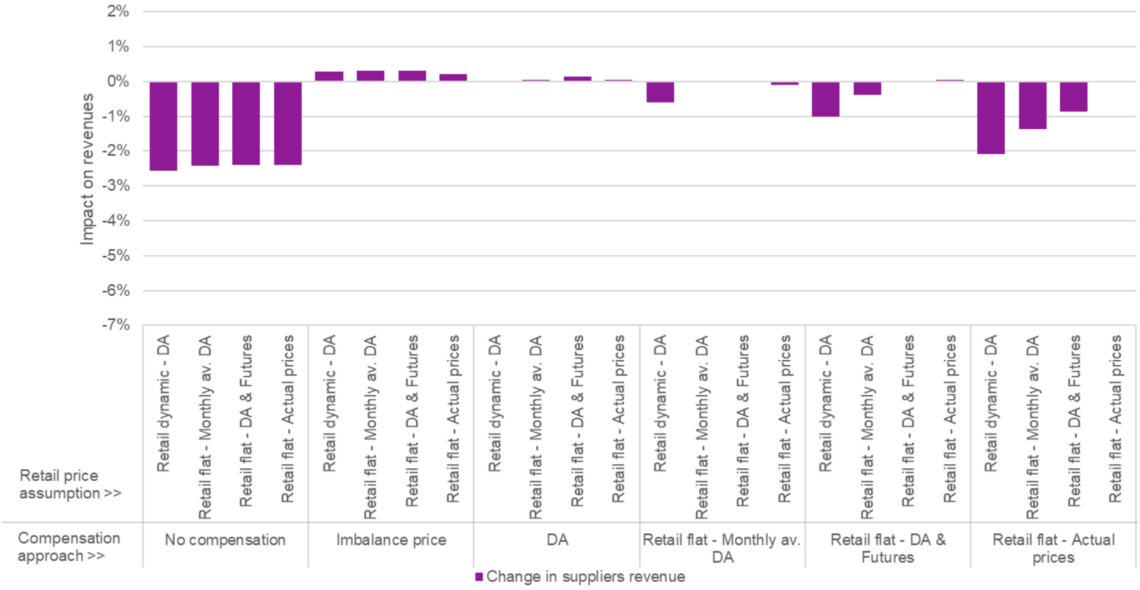

Figure 29 – Impact on suppliers' revenues from participating consumers due to activation in mFRR in Sweden

Note: average change in supplier's revenues for all Swedish bidding zones, for 2017-2021 and for 3 types of consumers (HPs / EVs with time-based activation constraints, and industrial consumers with an opportunity cost of 300€/MWh), depending on the retail price estimation approach and on the level of compensation.
Source: CL analysis based on data from ENTSO-E (FCR, FRR, DA) and Ei (ID).

In Sweden, as for the general case, a compensation reflecting retail prices would be the most suitable approach. Moreover, as the most common type of contracts in Sweden is open ended monthly variable, as shown in Table 6, a compensation based on day-ahead prices might therefore not reflect accurately retail prices for a large share of consumers, at least at residential and SME level.

Using such dynamic compensation approach might also act as a barrier to the explicit participation of DSF in pure energy markets such as the DA or the ID. Consumers would have no incentives to value their flexibility in such markets, neither through retail price signals, nor through IAs. A compensation price based on a blend of day-ahead prices and monthly flat retail price estimates, taking into account the actual proportion of dynamic pricing penetration, could therefore be a more adapted solution.

With respect to balancing markets, the negative impact of using the day-ahead prices for the compensation on IA revenues would likely be limited due to the high proportion of capacity remuneration. However, a dynamic compensation approach might also prevent the participation of DSF in the Swedish mFRR reserve, which does not involve capacity remuneration for now.

B.2.3 Detailed results – Denmark

Denmark is characterised by differences between its two bidding zones DK1 and DK2. Capacity prices tend indeed to be higher in DK2 than in DK1, as indicated in Figure 21. This is particularly true in the mFRR reserve, with reservation prices for upward products on average three times higher.

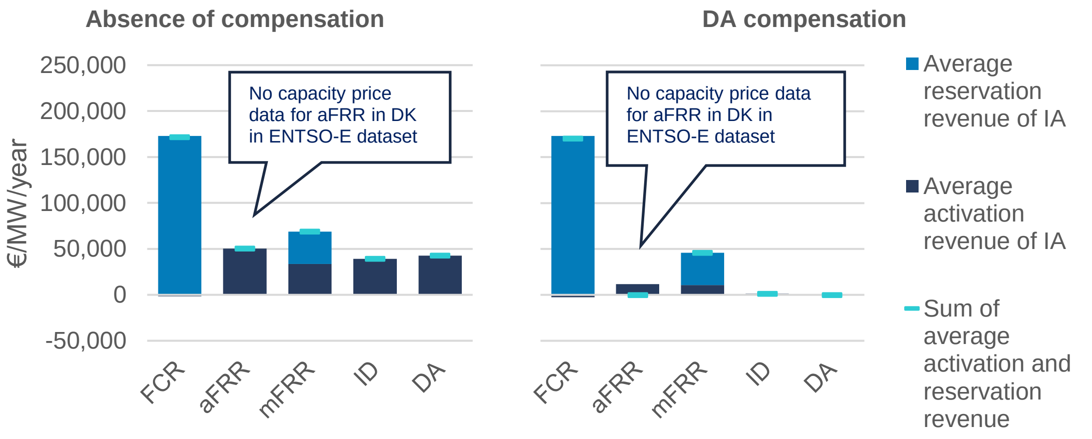

Figure 30 – Revenue of IA in the absence of compensation and with DA compensation in Denmark

Note: average revenue of IA for all bidding zones in Denmark and for years 2017-2021, for HPs and EVs with time-based activation constraints, and for industrial consumers with an opportunity cost of 300€/MWh.
Source: CL analysis based on data from ENTSO-E (FCR, FRR, DA) and Ei (ID).

Regarding the impact of compensation approaches on IAs, the activation revenues of the latter are in line with the average of other bidding zones in both DK1 and DK2.

However, regarding balancing reserves in DK1, as capacity remuneration tends to be relatively low in mFRR, the choice of compensation approach is central to enable the participation of DSF in this market segment. In particular, an hourly dynamic compensation approach (e.g. compensation set at the DA, the ID or the imbalance) could reduce the attractiveness of participating in this market. It should nonetheless be noted that with DA compensation, although lower than with a flat compensation approach, the revenues could be high enough to allow the participation of some aggregators. Total revenues with the approach are indeed above 20k€/MW/year on average in DK1 (literature[22] indicates that the minimum expected revenue of consumers to participate in energy markets typically starts around 15 k€/MW/year).

In DK2, as on average capacity prices appear to be higher than in DK1, the choice of compensation has an even lower impact in proportion, as the bulk of revenues would stem from capacity payments.

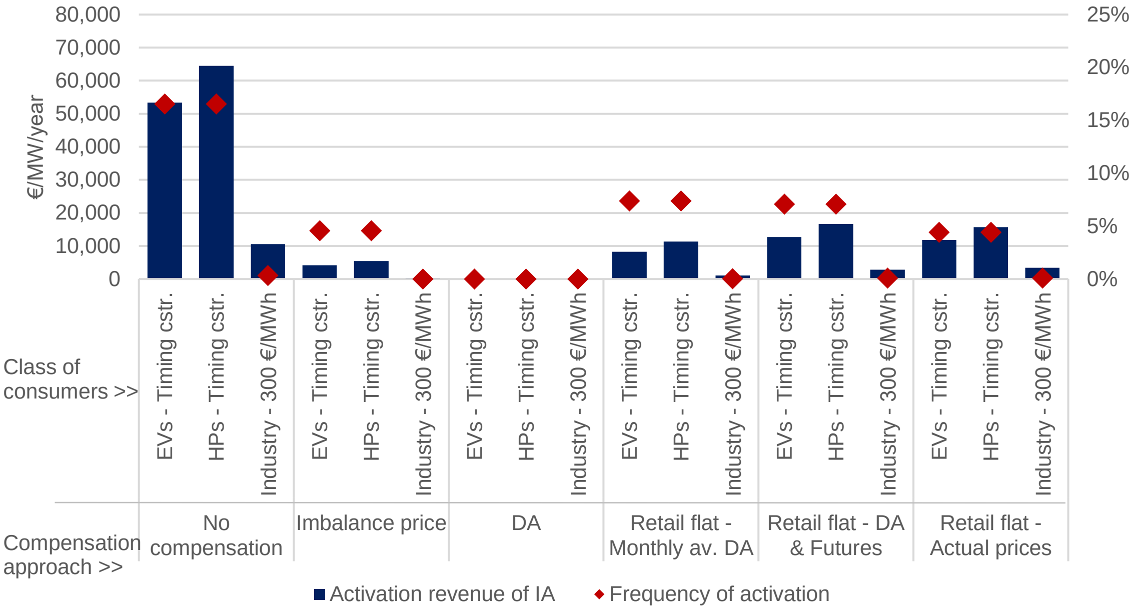

Figure 31 – Revenue of IA and frequency of activation for the participation in the DA market in Denmark

Note: average revenue of IA and average frequency of activation in the DA market for all bidding zones in Denmark and for 2017-2021, for HPs and EVs with time-based activation constraints, and for industrial consumers with an opportunity cost of 300€/MWh, depending on the level of compensation.
Source: CL analysis based on data from ENTSO-E (FCR, FRR, DA) and Ei (ID).

[22] Estimate based on (RTE, 2017).

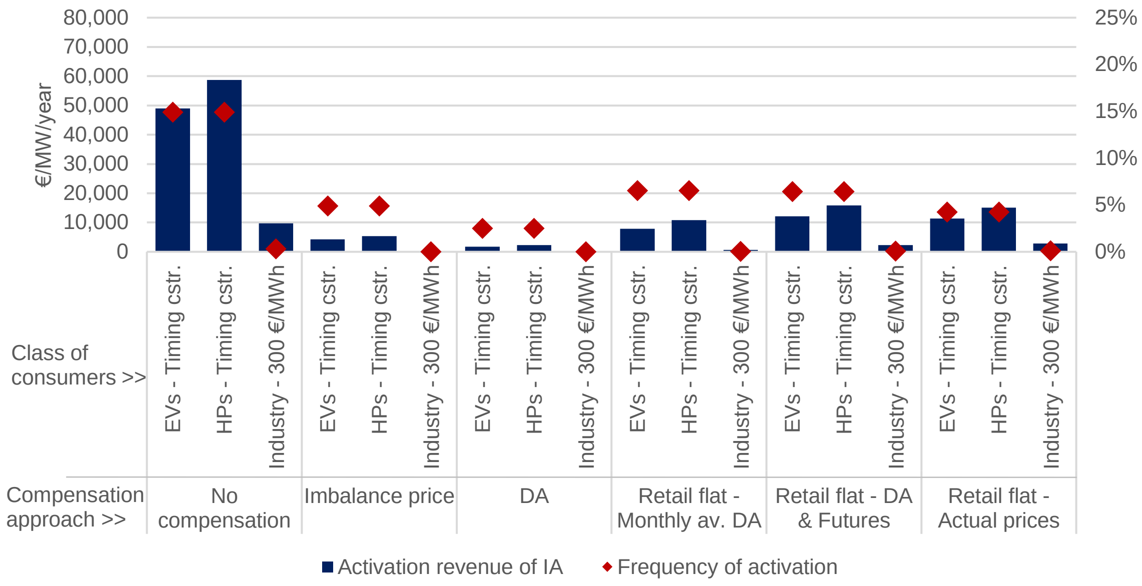

Figure 32 – Revenue of IA and frequency of activation for the participation in the ID market in Denmark

Note: average revenue of IA and average frequency of activation in the DA market for all bidding zones in Denmark and for 2017-2021, for HPs and EVs with time-based activation constraints, and for industrial consumers with an opportunity cost of 300€/MWh, depending on the level of compensation.
Source: CL analysis based on data from ENTSO-E (FCR, FRR, DA) and Ei (ID).

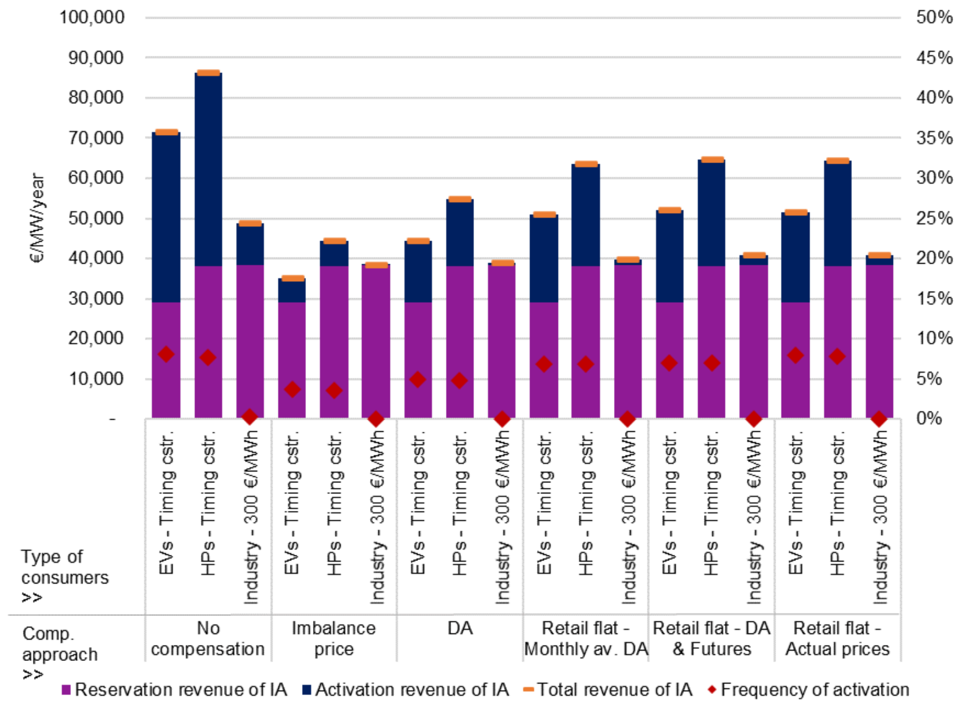

Figure 33 – Revenue of IA and frequency of activation for the participation in the mFRR market in Denmark

Note: average revenue of IA and average frequency of activation in the mFRR market in Denmark and for 2017-2021, for HPs and EVs with time-based activation constraints, and for industrial consumers with an opportunity cost of 300€/MWh, depending on the level of compensation.
Source: CL analysis based on data from ENTSO-E (FCR, FRR, DA) and Ei (ID).

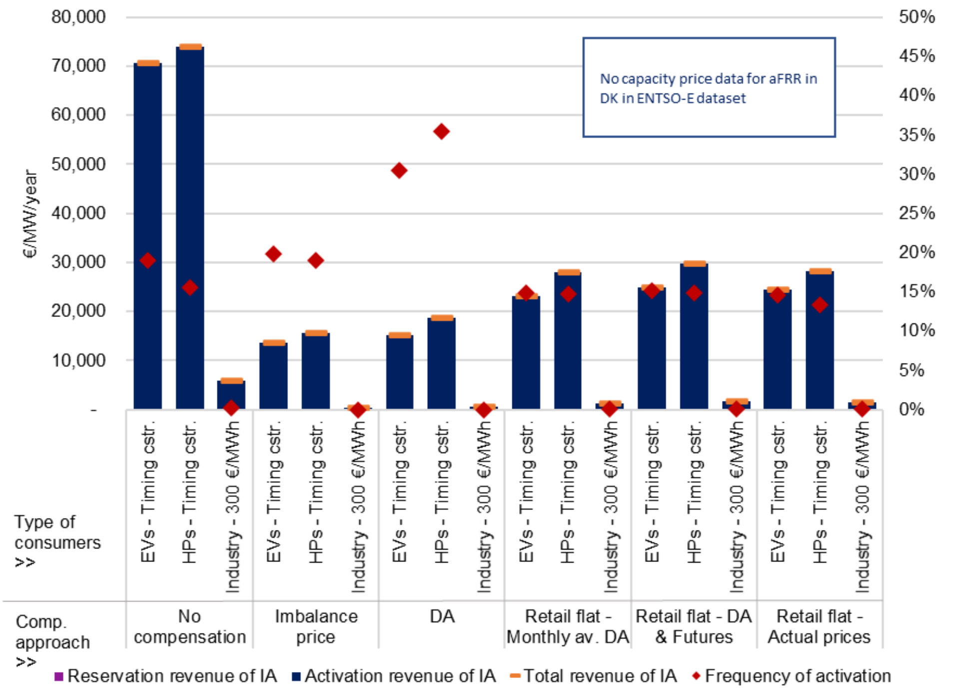

Figure 34 – Revenue of IA and frequency of activation for the participation in the aFRR market in Denmark

Note: average revenue of IA and average frequency of activation in the aFRR market for all bidding zones in Denmark and for 2017-2021, for HPs and EVs with time-based activation constraints, and for industrial consumers with an opportunity cost of 300€/MWh, depending on the level of compensation. For aFRR capacity prices, data published by the TSO at SE level are used for each bidding zone.
Source: CL analysis based on data from ENTSO-E (FCR, FRR, DA) and Ei (ID).

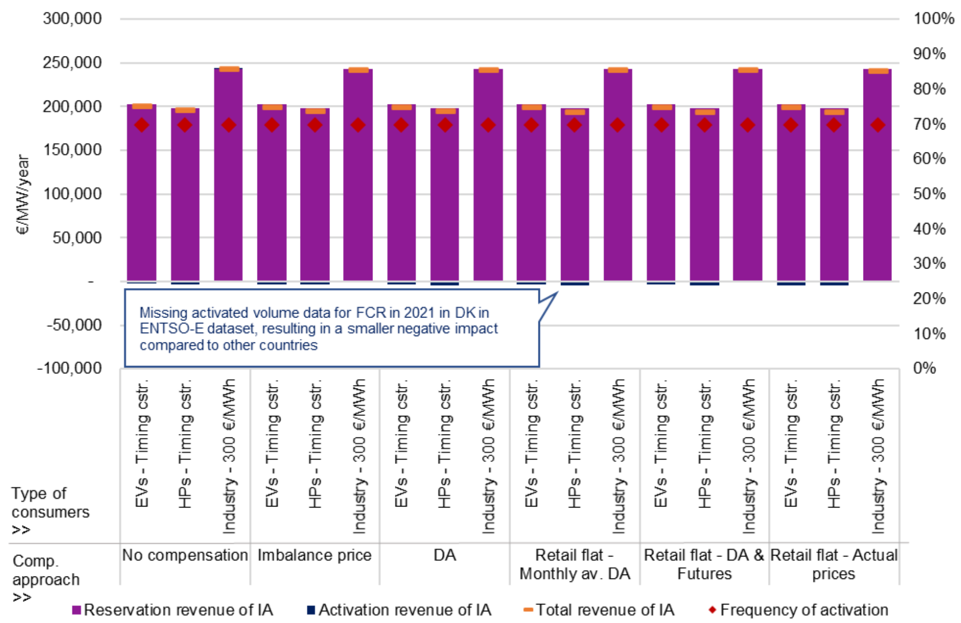

Figure 35 – Revenue of IA and frequency of activation for the participation in the FCR market in Denmark

Note: average revenue of IA and average frequency of activation in the FCR market for all bidding zones in Denmark and for 2017-2021, for HPs and EVs with time-based activation constraints, and for industrial consumers with an opportunity cost of 300€/MWh, depending on the level of compensation.
Source: CL analysis based on data from ENTSO-E (FCR, FRR, DA) and Ei (ID).

The impact on suppliers is, however, in line with values from other countries, with an average negative impact of revenues typically below 2% in the presence of compensation, as shown in Figure 36 and Figure 37.

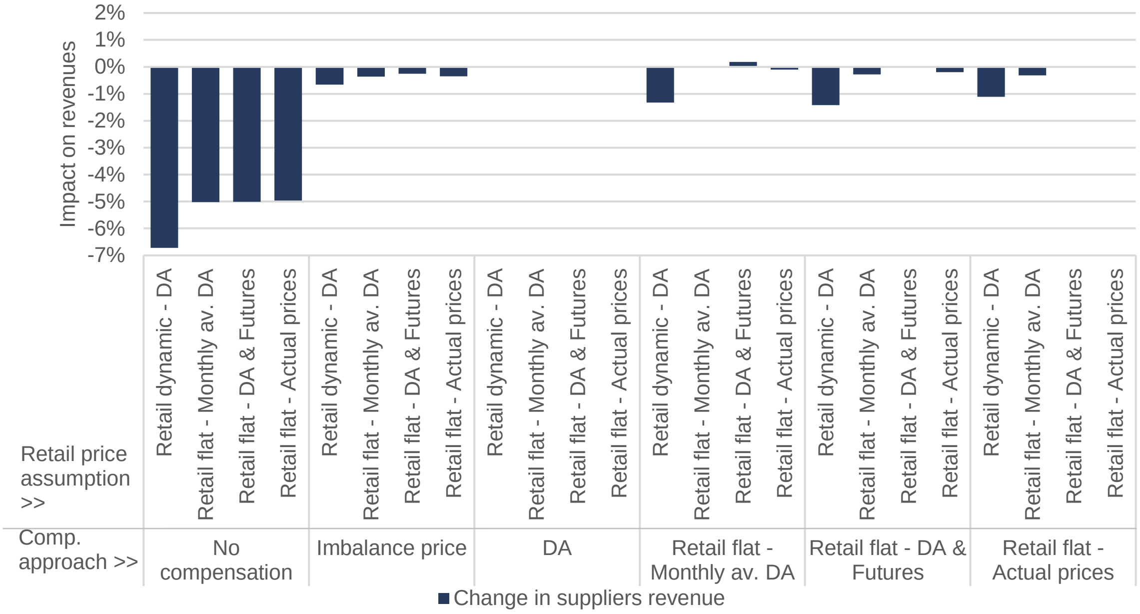

Figure 36 – Impact on suppliers' revenues from participating consumers due to activation in DA in Denmark

Note: average change in supplier's revenues for all bidding zones in Denmark, for 2017-2021 and for 3 types of consumers (HPs / EVs with time-based activation constraints, and industrial consumers with an opportunity cost of 300€/MWh), depending on the retail price estimation approach and on the level of compensation.
Source: CL analysis based on data from ENTSO-E (FCR, FRR, DA) and Ei (ID).

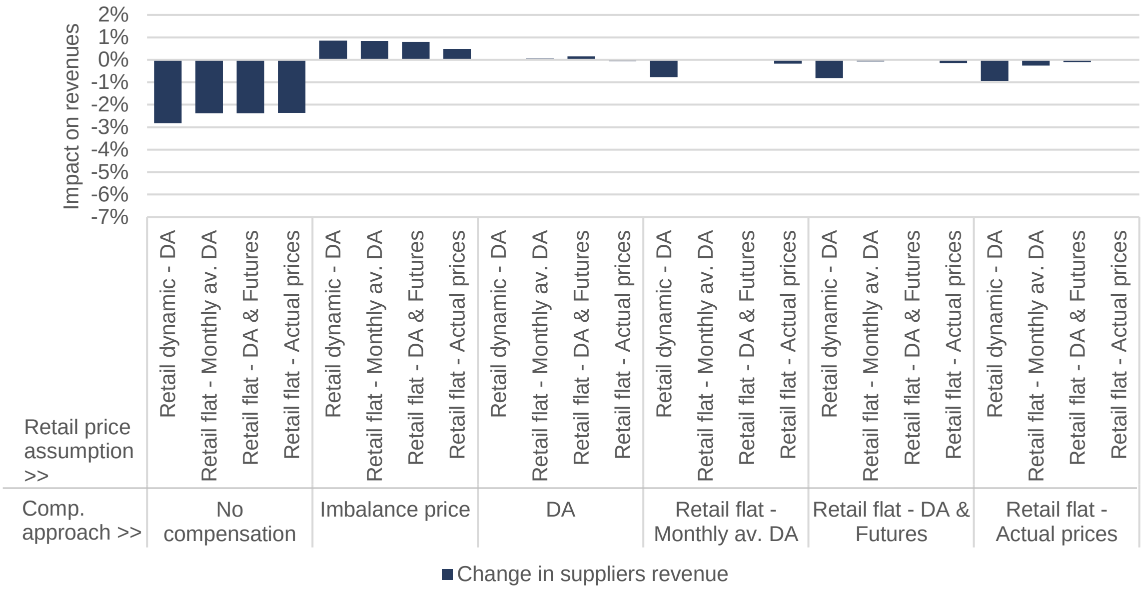

Figure 37 – Impact on suppliers' revenues from participating consumers due to activation in mFRR in Denmark

Note: average change in supplier's revenues for all bidding zones in Denmark, for 2017-2021 and for 3 types of consumers (HPs / EVs with time-based activation constraints, and industrial consumers with an opportunity cost of 300€/MWh), depending on the retail price estimation approach and on the level of compensation.
Source: CL analysis based on data from ENTSO-E (FCR, FRR, DA) and Ei (ID).

In Denmark, as for the general case, a compensation reflecting retail prices would be the most suitable approach. Moreover, although 43% of consumers are subject to variable price contracts, the most common type of contracts in Finland is fixed flat price contracts, as shown in Table 6. A compensation based on day-ahead prices might therefore not reflect accurately retail prices for a large share of consumers, at least at residential and SME level.

Using such dynamic compensation approach might also act as a barrier to the explicit participation of DSF in pure energy markets such as the DA or the ID. Consumers would have no incentives to value their flexibility in such markets, neither through retail price signals, nor through IAs. A compensation price based on a blend of day-ahead prices and flat retail price estimates, taking into account the actual proportion of dynamic pricing penetration, could therefore be a more adapted solution.

With respect to balancing markets, the negative impact of using the day-ahead prices for the compensation on IA revenues would likely be limited due to the high proportion of capacity remuneration. However, a dynamic compensation approach might reduce the attractiveness of participating in the mFRR market in DK1, which involves a relatively low level of capacity remuneration (although this impact is less significant than in the case of Sweden).

B.2.4 Detailed results – Finland

Compared with the other countries included in this study, Finland is characterised by relatively low capacity prices in the mFRR reserve and relatively high capacity prices in the aFRR reserve, as shown in Figure 21 and Figure 38.

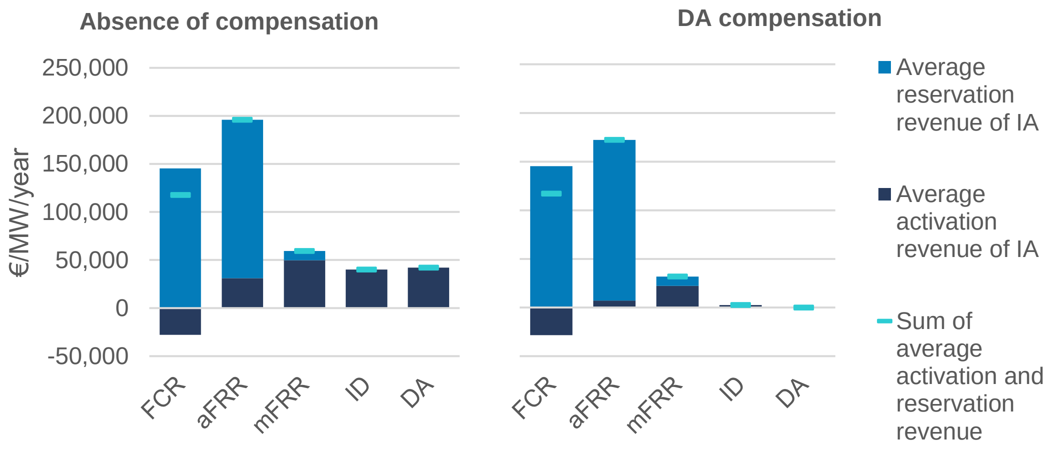

Figure 38 – Revenue of IA in the absence of compensation and with DA compensation in Finland

Note: average revenue of IA for all bidding zones in Finland and for years 2017-2021, for HPs and EVs with time-based activation constraints, and for industrial consumers with an opportunity cost of 300€/MWh.
Source: CL analysis based on data from ENTSO-E (FCR, FRR, DA) and Ei (ID).

Regarding the impact of compensation approaches on IAs, the activation revenues of the latter are in line with the average of other bidding zones. In FCR and aFRR, as on average capacity prices appear to be in line or higher than in other countries, the choice of compensation has an even lower impact in proportion, as the bulk of revenues would stem from capacity payments.

However, as capacity remuneration tends to be relatively low in mFRR, the choice of compensation approach is central to enable the participation of DSF in this market segment. In particular, an hourly dynamic compensation approach (e.g. compensation set at the DA, the ID or the imbalance) could reduce the attractiveness of participating in this market, as highlighted in Figure 41. It should nonetheless be noted that with DA compensation, although lower than with a flat compensation approach, the revenues could be high enough to allow the participation of some aggregators. Total revenues with the approach are indeed above 20k€/MW/year (literature[23] indicates that the minimum expected revenue of consumers to participate in energy markets typically starts around 15k€/MW/year).

[23] Estimate based on (RTE, 2017).

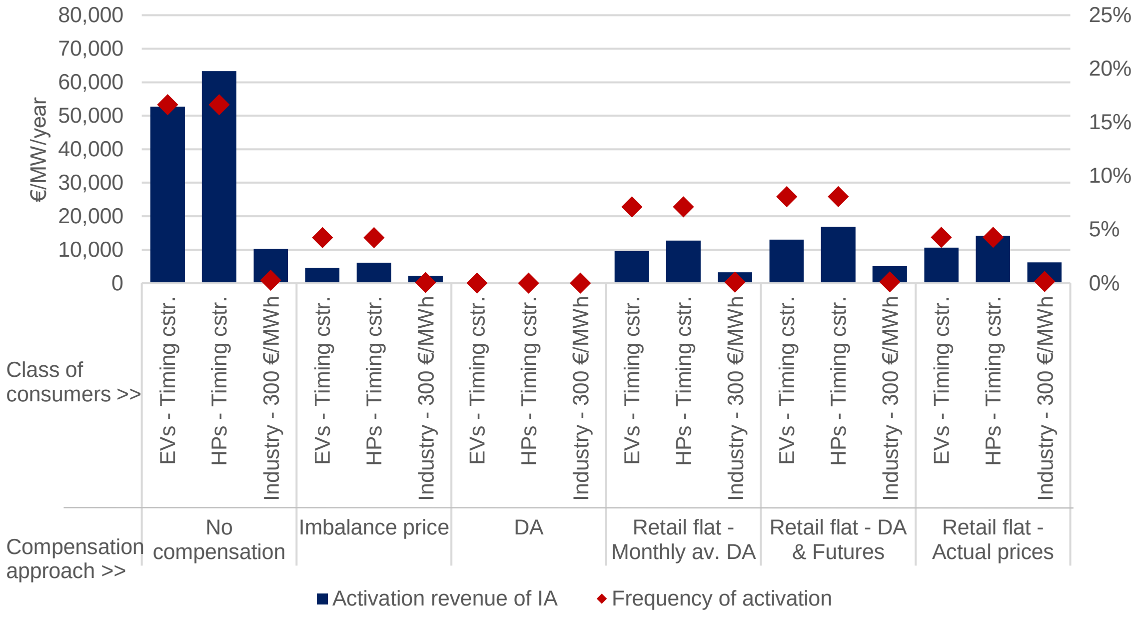

Figure 39 – Revenue of IA and frequency of activation for the participation in the DA market in Finland

Note: average revenue of IA and average frequency of activation in the DA market for all bidding zones Finland and for 2017-2021, for HPs and EVs with time-based activation constraints, and for industrial consumers with an opportunity cost of 300€/MWh, depending on the level of compensation.
Source: CL analysis based on data from ENTSO-E (FCR, FRR, DA) and Ei (ID).

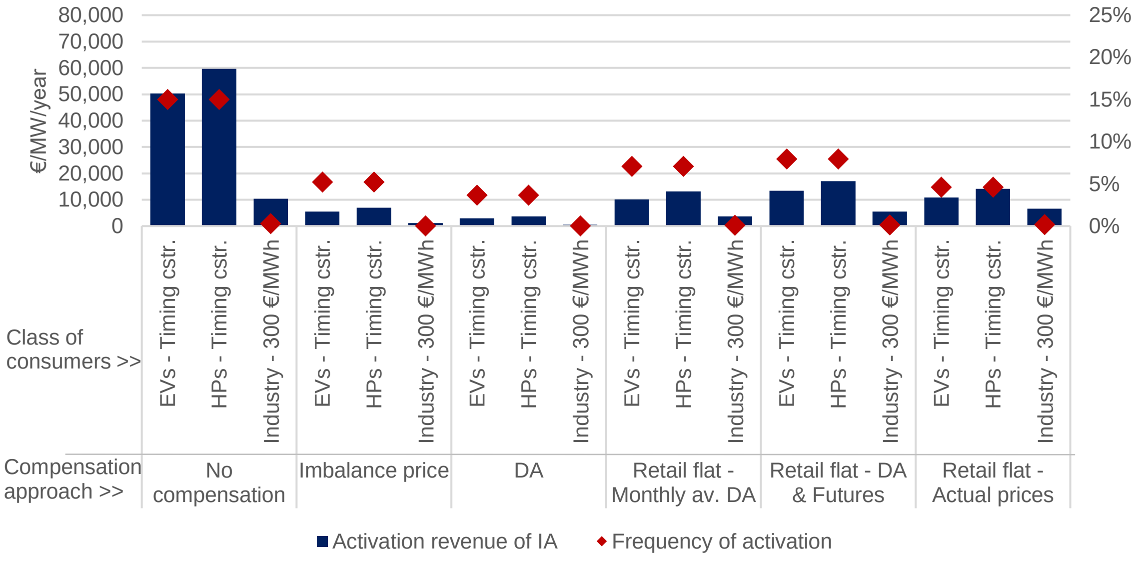

Figure 40 – Revenue of IA and frequency of activation for the participation in the ID market in Finland

Note: average revenue of IA and average frequency of activation in the DA market for all bidding zones in Finland and for 2017-2021, for HPs and EVs with time-based activation constraints, and for industrial consumers with an opportunity cost of 300€/MWh, depending on the level of compensation.
Source: CL analysis based on data from ENTSO-E (FCR, FRR, DA) and Ei (ID).

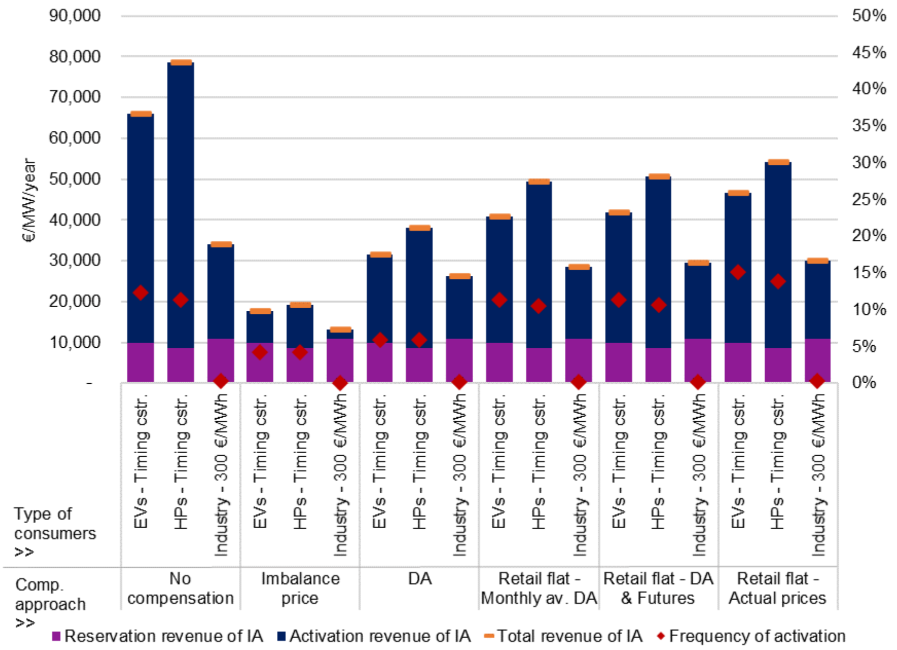

Figure 41 – Revenue of IA and frequency of activation for the participation in the mFRR market in Finland

Note: average revenue of IA and average frequency of activation in the mFRR market in Finland and for 2017-2021, for HPs and EVs with time-based activation constraints, and for industrial consumers with an opportunity cost of 300€/MWh, depending on the level of compensation.
Source: CL analysis based on data from ENTSO-E (FCR, FRR, DA) and Ei (ID).

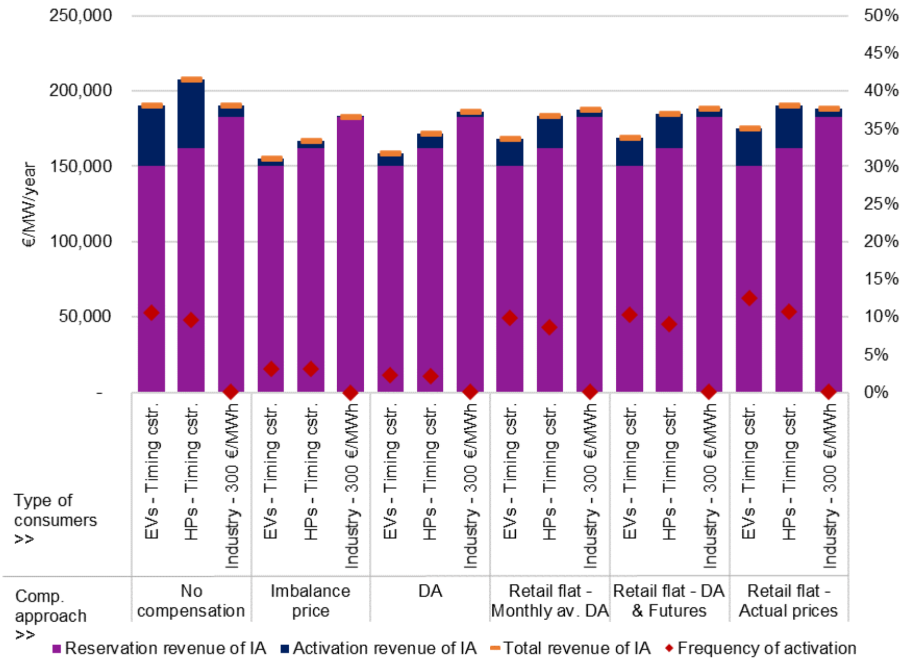

Figure 42 – Revenue of IA and frequency of activation for the participation in the aFRR market in Finland

Note: average revenue of IA and average frequency of activation in the aFRR market for all bidding zones in Finland and for 2017-2021, for HPs and EVs with time-based activation constraints, and for industrial consumers with an opportunity cost of 300€/MWh, depending on the level of compensation. For aFRR capacity prices, data published by the TSO at SE level are used for each bidding zone.
Source: CL analysis based on data from ENTSO-E (FCR, FRR, DA) and Ei (ID).

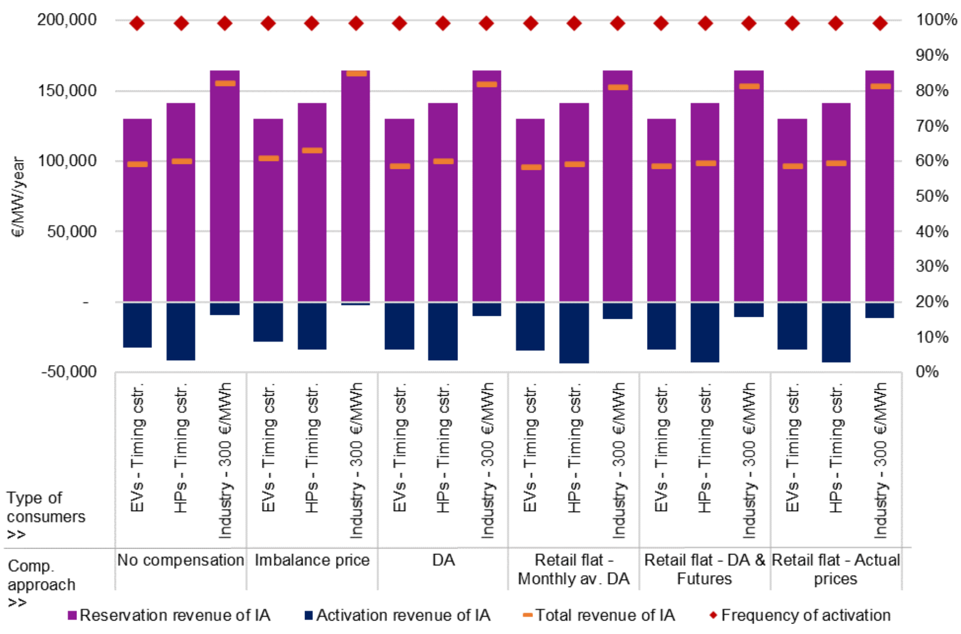

Figure 43 – Revenue of IA and frequency of activation for the participation in the FCR market in Finland

Note: average revenue of IA and average frequency of activation in the FCR market for all bidding zones in Finland and for 2017-2021, for HPs and EVs with time-based activation constraints, and for industrial consumers with an opportunity cost of 300€/MWh, depending on the level of compensation.
Source: CL analysis based on data from ENTSO-E (FCR, FRR, DA) and Ei (ID).

The impact on suppliers is, however, in line with values from other countries, with an average negative impact of revenues typically around or below 2% in the presence of compensation, as shown in Figure 44 and Figure 45.

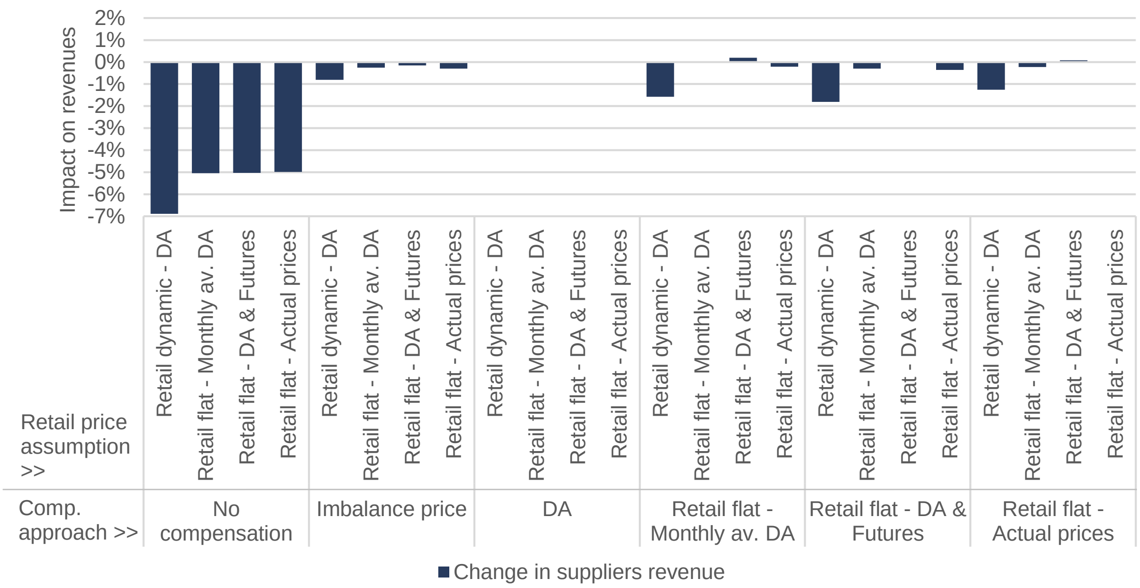

Figure 44 – Impact on suppliers' revenues from participating consumers due to activation in DA in Finland

Note: average change in supplier's revenues for all bidding zones in Finland, for 2017-2021 and for 3 types of consumers (HPs / EVs with time-based activation constraints, and industrial consumers with an opportunity cost of 300€/MWh), depending on the retail price estimation approach and on the level of compensation.

Source: CL analysis based on data from ENTSO-E (FCR, FRR, DA) and Ei (ID).

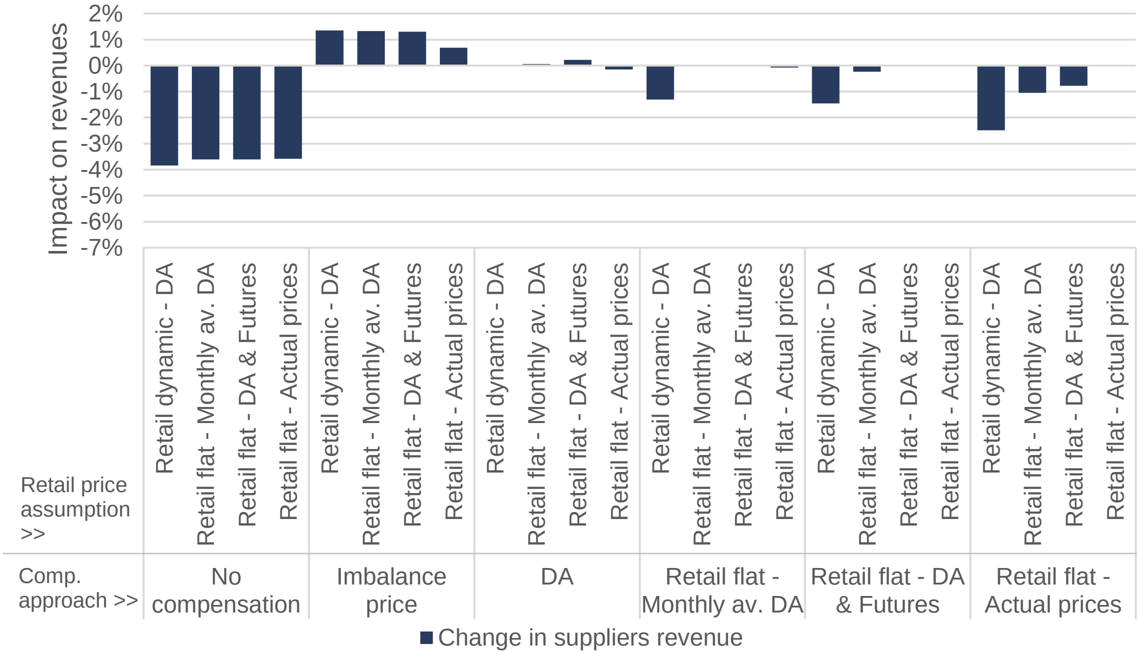

Figure 45 – Impact on suppliers' revenues from participating consumers due to activation in mFRR in Finland

Note: average change in supplier's revenues for all bidding zones in Finland, for 2017-2021 and for 3 types of consumers (HPs / EVs with time-based activation constraints, and industrial consumers with an opportunity cost of 300€/MWh), depending on the retail price estimation approach and on the level of compensation.
Source: CL analysis based on data from ENTSO-E (FCR, FRR, DA) and Ei (ID).

In Finland, as for the general case, a compensation reflecting retail prices would be the most suitable approach. Moreover, as the most common type of contracts in Finland is fixed flat price contracts, as shown in Table 6, a compensation based on day-ahead prices might therefore not reflect accurately retail prices for a large share of consumers, at least at residential and SME level.

Using such dynamic compensation approach might also act as a barrier to the explicit participation of DSF in pure energy markets such as the DA or the ID. Consumers would have no incentives to value their flexibility in such markets, neither through retail price signals, nor through IAs. A compensation price based on a blend of day-ahead prices and flat retail price estimates, taking into account the actual proportion of dynamic pricing penetration, could therefore be a more adapted solution.

With respect to balancing markets, the negative impact of using the day-ahead prices for the compensation on IA revenues would likely be limited due to the high proportion of capacity remuneration. However, a dynamic compensation approach might reduce the attractiveness of participating in the mFRR market, which involves a relatively low level of capacity remuneration (although this impact is less significant than in the case of Sweden).

B.2.5 Detailed results – Norway

Compared with the other countries included in this study, Norway is characterised by relatively low capacity prices in balancing reserves, as shown in Figure 21 and Figure 46. Although the average revenues from mFRR participation in NO1, NO2 and NO5 are relatively high, these average values are driven up by very high reservation prices in December and November 2021 for weekly capacity products (up to 1000€/MW/h). Moreover, price levels in pure energy markets tend to be higher in southern bidding zones (NO1, NO2 and NO5) than in northern bidding zones (NO3 and NO4). For instance, between 2017 and 2021, DA prices in NO1, NO2 and NO5 are on average 24% higher than in NO3 and NO4.

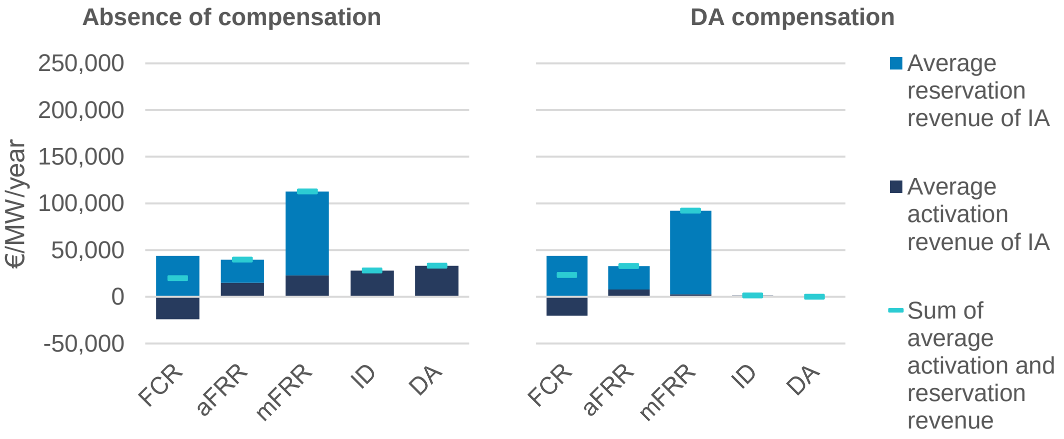

Figure 46 – Revenue of IAs in the absence of compensation and with DA compensation in Norway

Note: average revenue of IA for all bidding zones in Norway and for years 2017-2021, for HPs and EVs with time-based activation constraints, and for industrial consumers with an opportunity cost of 300€/MWh.
Source: CL analysis based on data from ENTSO-E (FCR, FRR, DA) and Ei (ID).

Regarding the impact of compensation approaches on IAs, the activation revenues of the latter are in line with the average of other bidding zones. In balancing reserves, as capacity prices tend to be lower than in other countries, the choice of compensation can have a more important impact in proportion compared with other countries, even though the bulk of revenues would stream from capacity payments. This is particularly apparent in Figure 50, in the aFRR reserve.

In particular, the impact of an hourly dynamic compensation approach (e.g. compensation set at the DA, the ID or the imbalance) would have in proportion a stronger negative impact on the business case of DSF in balancing reserves compared with other countries, as highlighted in Figure 50.

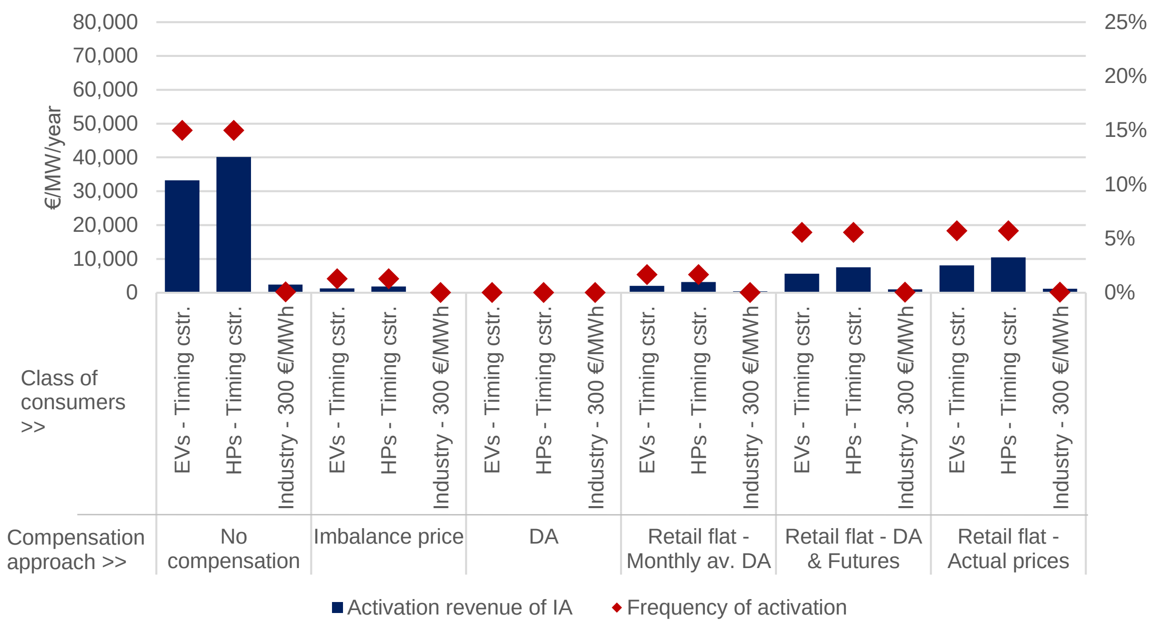

Figure 47 – Revenue of IA and frequency of activation for the participation in the DA market in Norway

Note: average revenue of IA and average frequency of activation in the DA market for all bidding zones in Norway and for 2017-2021, for HPs and EVs with time-based activation constraints, and for industrial consumers with an opportunity cost of 300€/MWh, depending on the level of compensation.
Source: CL analysis based on data from ENTSO-E (FCR, FRR, DA) and Ei (ID).

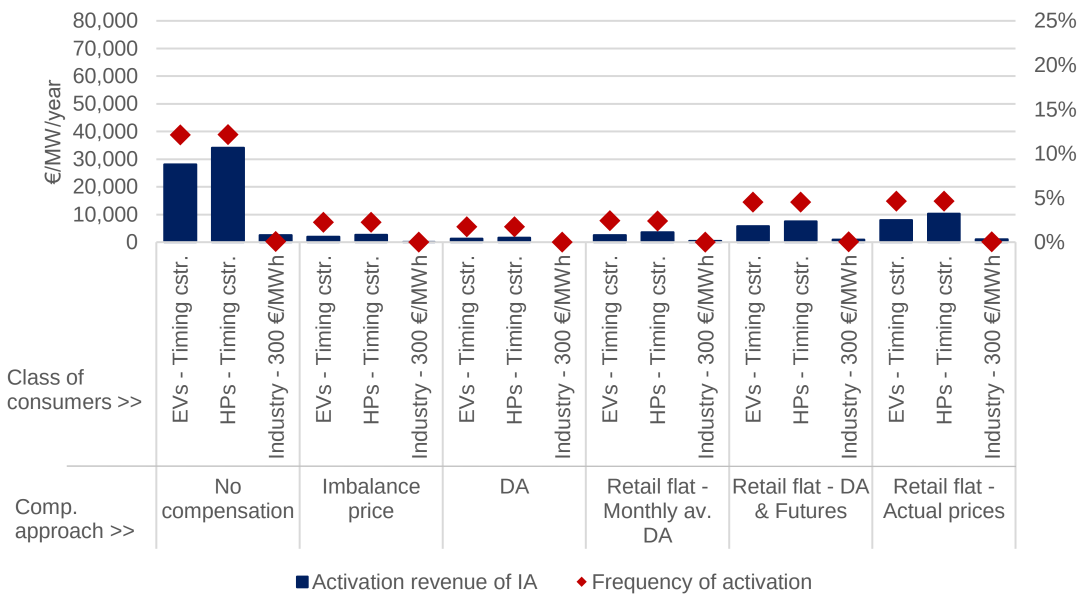

Figure 48 – Revenue of IA and frequency of activation for the participation in the ID market in Norway

Note: average revenue of IA and average frequency of activation in the DA market for all bidding zones in Norway and for 2017-2021, for HPs and EVs with time-based activation constraints, and for industrial consumers with an opportunity cost of 300€/MWh, depending on the level of compensation.
Source: CL analysis based on data from ENTSO-E (FCR, FRR, DA) and Ei (ID).

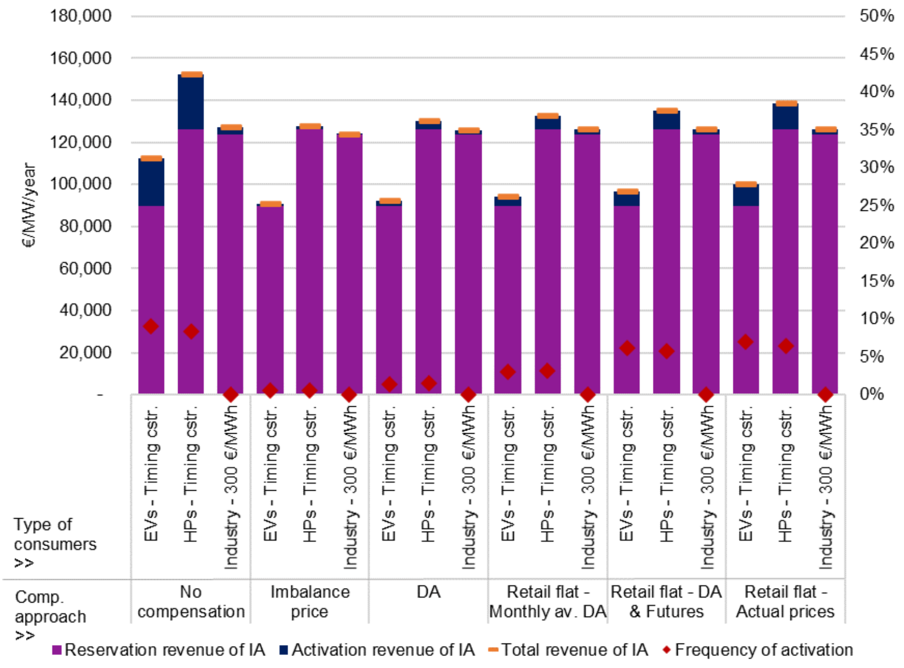

Figure 49 – Revenue of IA and frequency of activation for the participation in the mFRR market in Norway

Note: average revenue of IA and average frequency of activation in the mFRR market in Norway and for 2017-2021, for HPs and EVs with time-based activation constraints, and for industrial consumers with an opportunity cost of 300€/MWh, depending on the level of compensation.
Source: CL analysis based on data from ENTSO-E (FCR, FRR, DA) and Ei (ID).

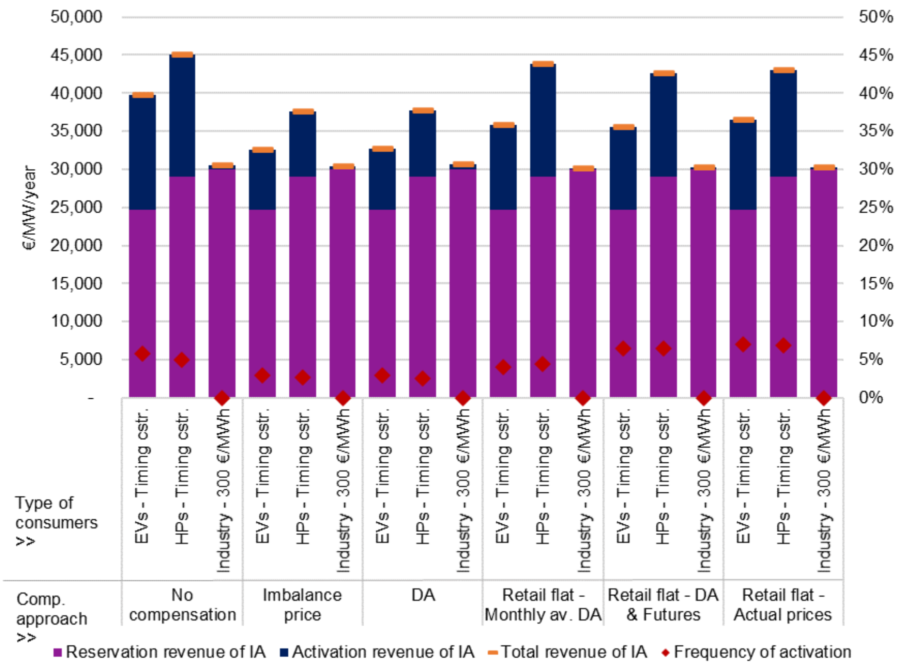

Figure 50 - Revenue of IA and frequency of activation for the participation in the aFRR market in Norway

Note: average revenue of IA and average frequency of activation in the aFRR market in Norway and for 2017-2021, for HPs and EVs with time-based activation constraints, and for industrial consumers with an opportunity cost of 300€/MWh, depending on the level of compensation.
Source: CL analysis based on data from ENTSO-E (FCR, FRR, DA) and Ei (ID).

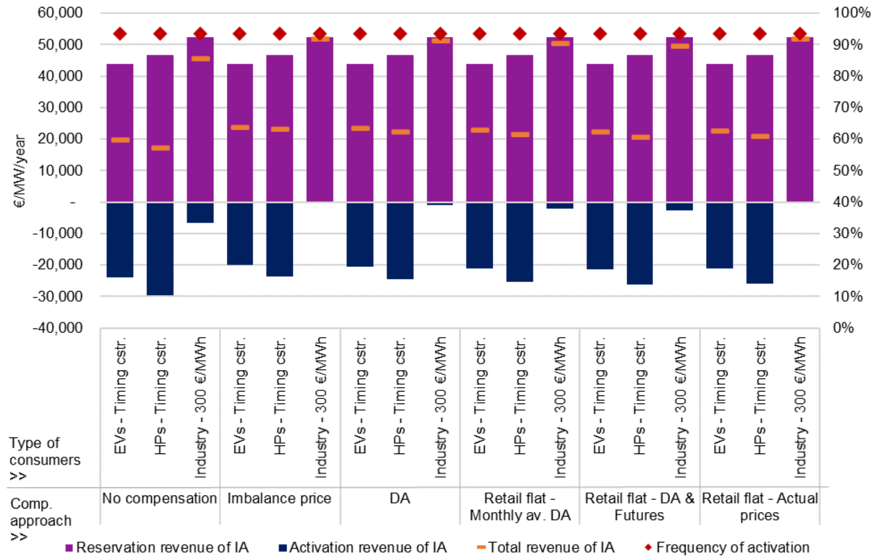

Figure 51 – Revenue of IA and frequency of activation for the participation in the FCR market in Norway

Note: average revenue of IA and average frequency of activation in the FCR market for all bidding zones in Norway and for 2017-2021, for HPs and EVs with time-based activation constraints, and for industrial consumers with an opportunity cost of 300€/MWh, depending on the level of compensation.
Source: CL analysis based on data from ENTSO-E (FCR, FRR, DA) and Ei (ID).

The impact on suppliers is, however, in line with values from other countries, with an average negative impact of revenues typically around or below 2% in the presence of compensation, as shown in Figure 52 and Figure 53.

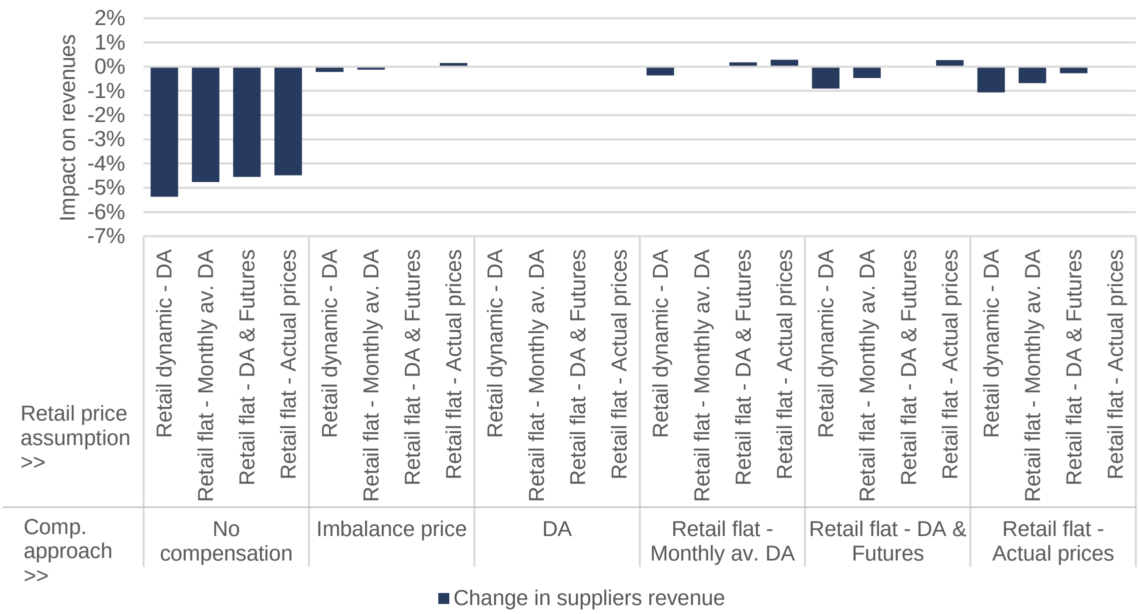

Figure 52 – Impact on suppliers' revenues from participating consumers due to activation in DA in Norway

Note: average change in supplier's revenues for all bidding zones in Norway, for 2017-2021 and for 3 types of consumers (HPs / EVs with time-based activation constraints, and industrial consumers with an opportunity cost of 300€/MWh), depending on the retail price estimation approach and on the level of compensation.
Source: CL analysis based on data from ENTSO-E (FCR, FRR, DA) and Ei (ID).

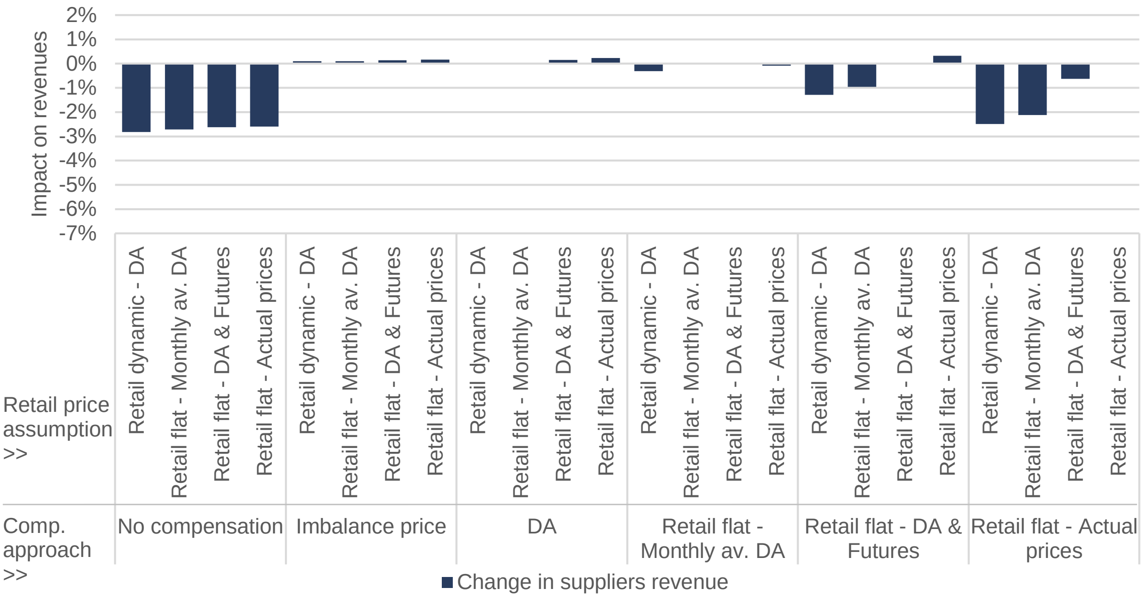

Figure 53 – Impact on suppliers' revenues from participating consumers due to activation in mFRR in Norway

Note: average change in supplier's revenues for all bidding zones in Norway, for 2017-2021 and for 3 types of consumers (HPs / EVs with time-based activation constraints, and industrial consumers with an opportunity cost of 300€/MWh), depending on the retail price estimation approach and on the level of compensation.
Source: CL analysis based on data from ENTSO-E (FCR, FRR, DA) and Ei (ID).

In Norway, as for the general case, a compensation reflecting retail prices would be the most suitable approach. Moreover, as ~75% of contracts in Norway are hourly dynamic price contracts, as shown in Table 6, a compensation based on day-ahead prices might therefore reflect accurately retail prices for a large share of consumers.

While using such dynamic compensation approach might act as a barrier to the participation of IAs in pure energy markets such as the DA or the ID, this would not necessarily prevent DSF from being active in these markets, as a large proportion receive an incentive through their dynamic retail tariff.

With respect to balancing markets, the negative impact of using dynamic compensation approaches would likely be more important than in other Nordic countries, due to the more limited levels of capacity remuneration in these markets. A compensation price based on a blend of day-ahead prices and flat retail price estimates, taking into account the actual proportion of dynamic pricing penetration, could therefore be a more adapted solution.

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