Assessment of the balancing revenues earned by technologies in the Belgian electricity market

Final Report

Compass Lexecon

14 November 2023

Disclaimer

- This presentation has been prepared by FTI France SAS (“FTI”, trading under “Compass Lexecon”) for ELIA (the “Client”) under the terms of the Client’s engagement letter with FTI (the “Contract”).
- This presentation has been prepared solely for the benefit of the Client. No other party than the Client is entitled to rely on this presentation for any purpose whatsoever without the previous consent from the Client and FTI.
- This presentation may not be supplied to any third parties without FTI’s prior written consent which may be conditional upon any such third party entering into a hold harmless letter with FTI on terms agreed by FTI. FTI accepts no liability or duty of care to any person (except to the Client under the relevant terms of the Contract) for the content of the presentation. Accordingly, FTI disclaims all responsibility for the consequences of any person (other than the Client on the above basis) acting or refraining to act in reliance on the presentation or for any decisions made or not made which are based upon such presentation.
- The presentation contains information obtained or derived from a variety of sources. FTI does not accept any responsibility for verifying or establishing the reliability of those sources or verifying the information so provided.
- Nothing in this material constitutes investment, legal, accounting or tax advice, or a representation that any investment or strategy is suitable or appropriate to the recipient’s individual circumstances, or otherwise constitutes a personal recommendation.
- No representation or warranty of any kind (whether express or implied) is given by FTI to any person (except to the Client under the relevant terms of the Contract) as to the accuracy or completeness of the presentation.
- The presentation is based on information available to FTI at the time of writing of the presentation and does not take into account any new information which becomes known to us after the date of the presentation. We accept no responsibility for updating the presentation or informing any recipient of the presentation of any such new information.
- This presentation and its contents are confidential and may not be copied or reproduced without the prior written consent of FTI.
- All copyright and other proprietary rights in the presentation remain the property of FTI and all rights are reserved.

Outline

- Introduction and project background
- Methodology for the calculation of net revenues
- Overview of econometric results
- Net revenue results
- Crisis adjustment and other adjustments

1.

Project background and overview

As part of the Capacity Market yearly calibration, Elia needs to define global and intermediate price caps

As part of the yearly calibration of the Belgian CRM, Elia is required to calculate the missing money of different technologies

- **Elia provides input for defining CRM parameters** to be used for yearly calibration cycles, following the Royal Decree Methodology and the Electricity Act
- As part of the yearly cycle, **Elia is required to conduct a "missing money" assessment for different technologies**, feeding into: (i) the CRM demand curve (Art. 10; final proposal made by CREG) (ii) the global auction price cap (Art. 10), (iii) the intermediate price caps (Art. 19 and 22)

The evaluation of the missing money of different technologies requires an assessment of their net balancing revenues

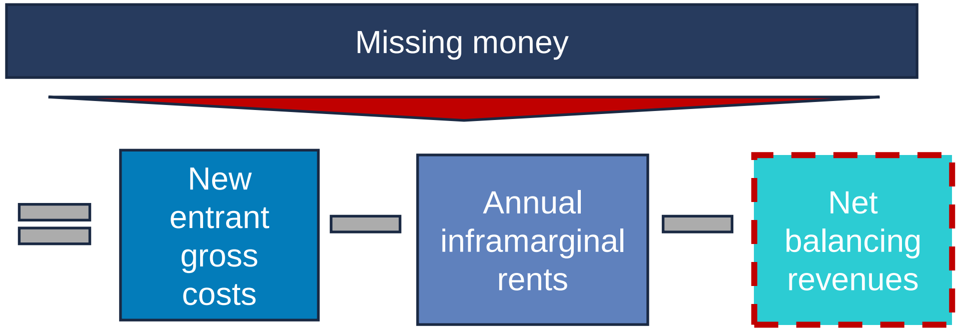
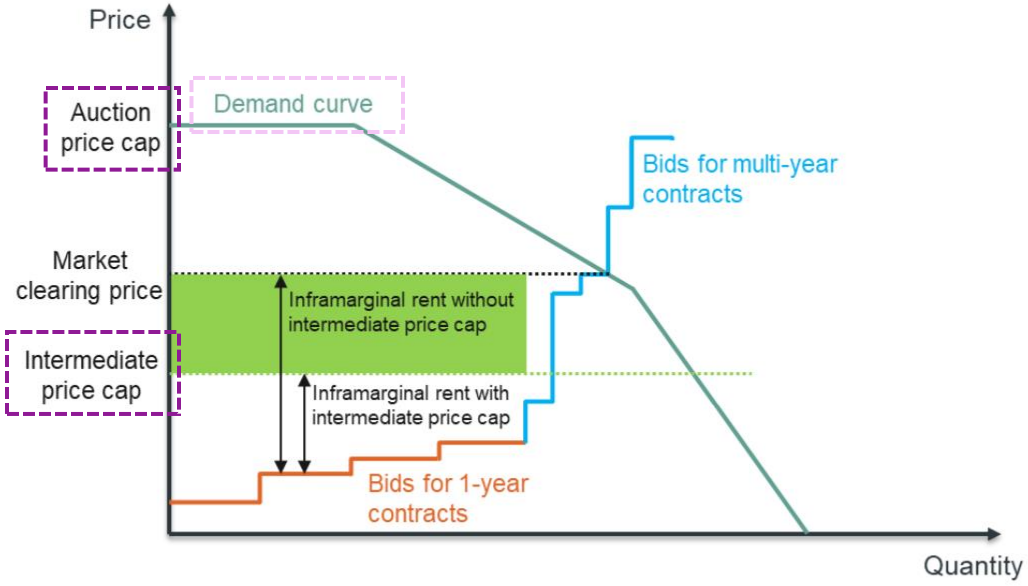


Illustration of the parameters requiring a missing money assessment for the yearly Belgian CRM calibration



Source: Elia (2019)

Elia is required by the Royal Decree Methodology to provide inputs to define the intermediate and global auction price caps, which requires the calculation of net balancing revenues for different technologies

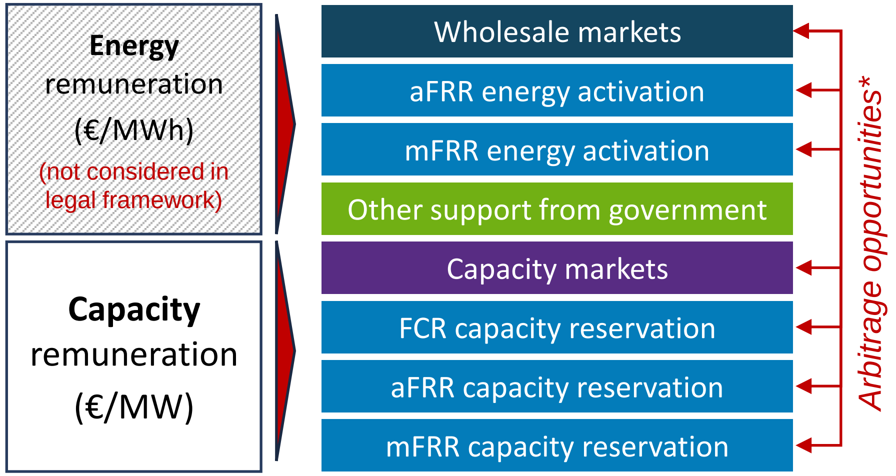
Source: Royal Decree Methodology (2021), Electricity Act (1999)

Note: The demand curve is defined by the Minister based on a proposal made by CREG and on inputs and calculations by ELIA.

The net balancing revenue calculation follows a general methodology set by Royal Decree, accounting for arbitrage opportunities across markets

- **According to articles 10, 19 and 22 of the Royal Decree Methodology**, the estimated net revenue obtained from the provision of balancing services:
  1. Is **evaluated for each relevant technology**, defined separately for the purpose of the global auction cap, as well as for intermediate price cap
  2. **Corresponds to the average historical costs of reservation** by the system operator for services intended for balancing regulation, for **the last 36 months**
  3. **Takes into account the costs, including opportunity costs, related to participation in balancing markets**, in order to avoid double counting between inframarginal rents and market revenues from ancillary balancing services.
- Indeed, **there is an arbitrage between balancing market participation and wholesale markets**, and this effect should be untangled to calculate net balancing revenues

Market participants have to arbitrage across multiple markets to maximise their revenues



Strictly speaking, the Royal Decree Methodology only considers reservation. However, the present assessment targets a broader framework by looking at both reservation & activation revenues.

Source: Royal Decree Methodology (2021)

*Due to the reliability option mechanism, there is an arbitrage between the CM and wholesale markets.

Overview of our proposed approach

4 workstreams in line with our understanding of Elia's needs

Workstream	Description
Workstream 1 – Qualitative methodology analysis	**Qualitative assessment of Elia's existing methodologies** for the calculation of net balancing revenues
Workstream 2 – Historical review of gross balancing revenues	**Quantify and review historical gross balancing revenues** by technologies in Belgium
Workstream 3 – Econometric analysis of gross balancing revenues	**Test the appropriateness of Elia's methodology for calculating net balancing revenues**
Workstream 4 – Methodological recommendations	**Identify and assess methodological improvements** for the calculation of net balancing revenues

2.

Methodology for the calculation of net revenues

To calculate net balancing revenues, we propose a different approach to the one previously taken by Elia

COMPASS LEXECON

Compass Lexecon's proposed net balancing revenue methodology

Actual reservation and activation revenue for each technology by CCTU

Develop cost assumptions, including opportunity costs, for each technology in activation and reservation

Subtract direct and opportunity costs from revenues of each technology/ market, with a daily/ CCTU granularity

Convert revenues to €/kW/year using installed capacity data

Net balancing revenue by technology

Future revenue adjustments

elia

Elia's previous methodology (Y-4 auction 2027-2028)

Maximum theoretical annual reservation revenue
average reservation price x 8760

Correction coefficients

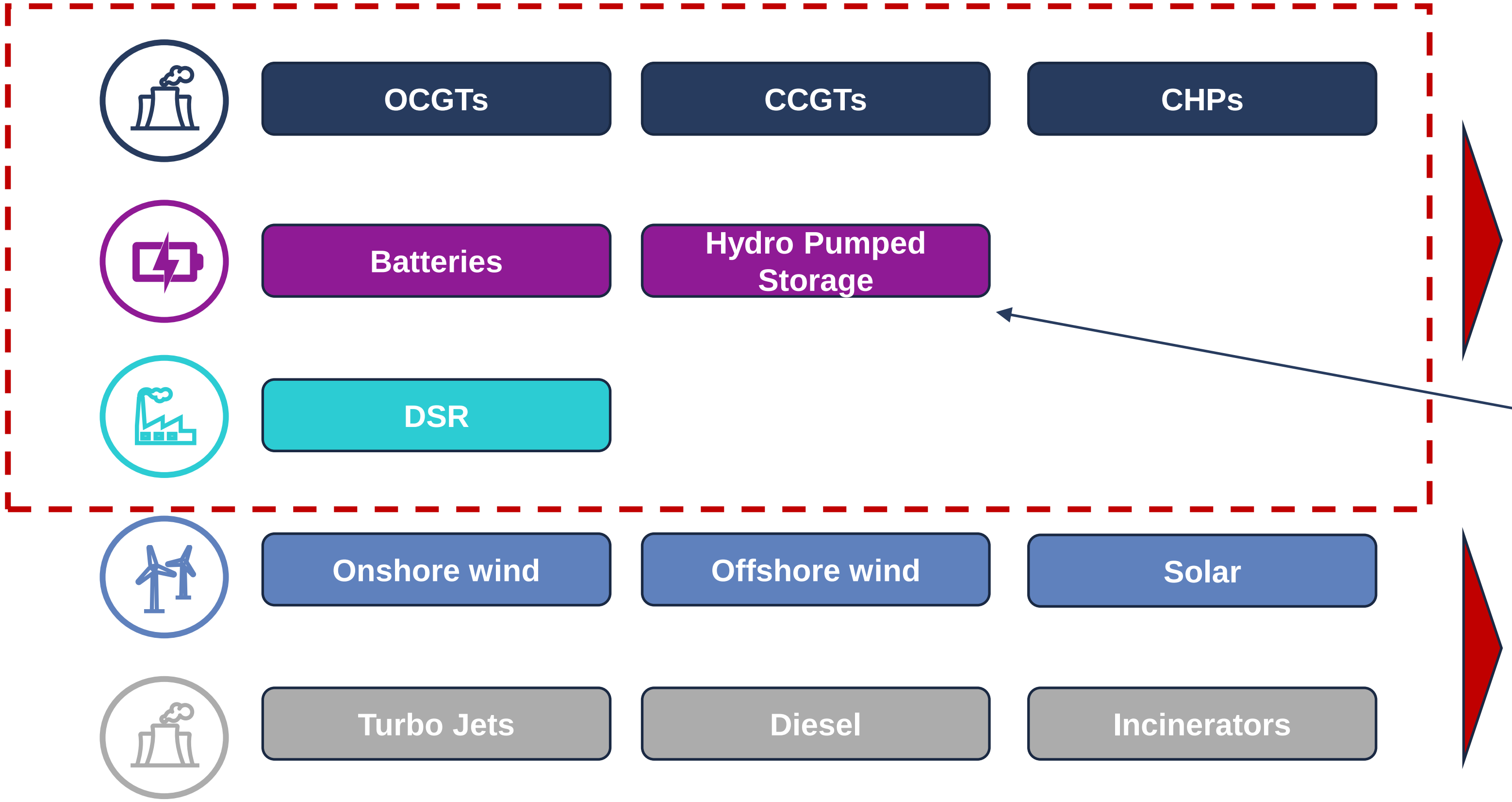
% coefficient depending on volume requirement compared to installed capacity

% coefficient depending on future market developments

% coefficient to factor in opportunity costs

Final net balancing revenue by technology

For this study, we focus on the net revenues of gas units, storage assets and demand side response



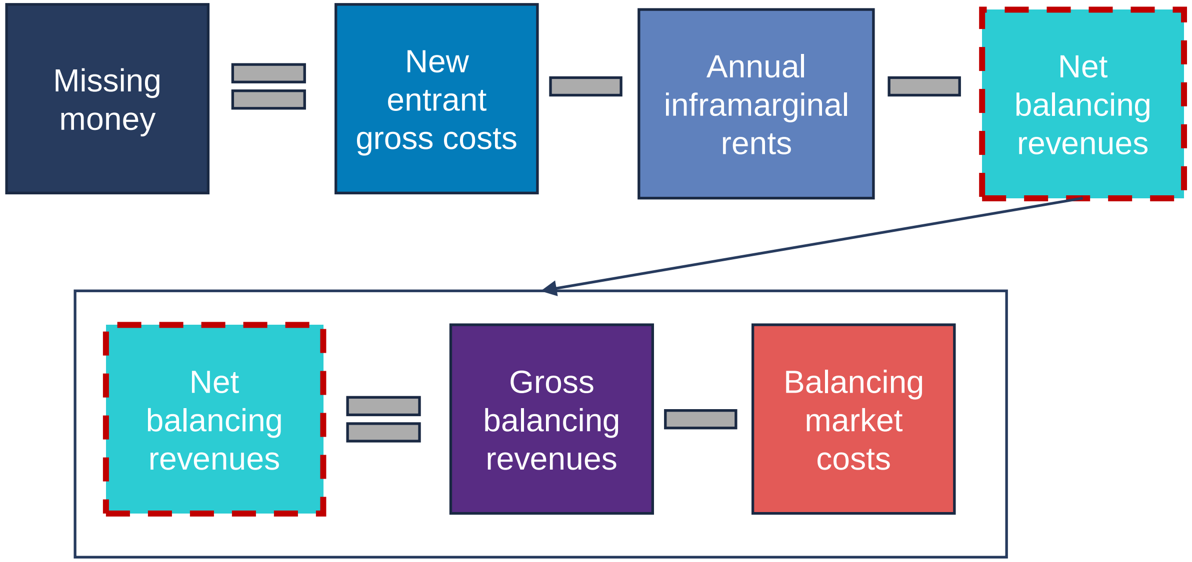
Key technologies in focus for this study

Note : hydro has been hidden from this presentation to preserve confidentiality on market participant data

Technologies deprioritised for this study, due to lower relevance for the CRM and/or negligible balancing revenues

The calculation of net balancing revenues first requires the calculation of gross balancing revenues

The evaluation of the missing money of different technologies requires an assessment of their net balancing revenues

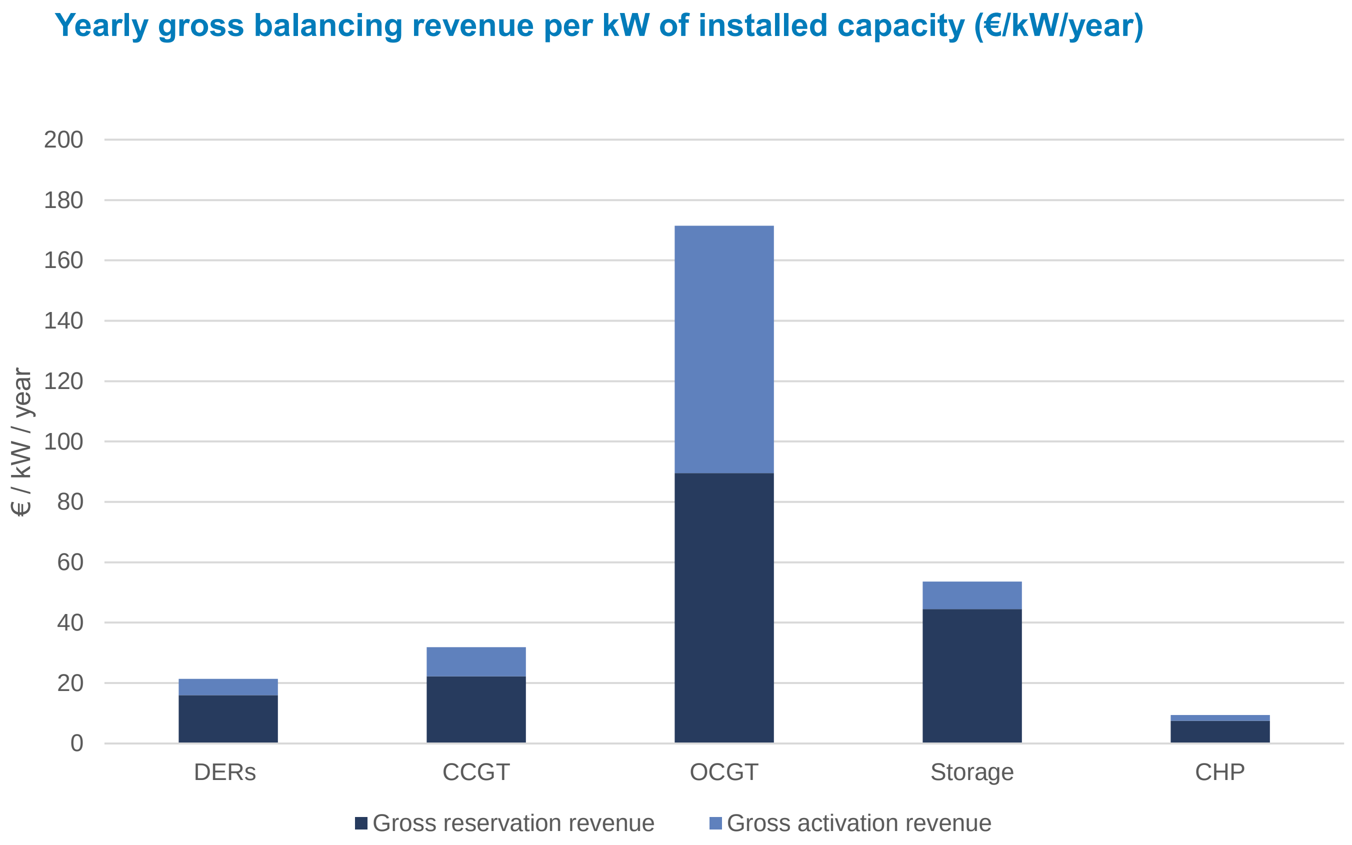


- **Gross balancing revenues** are the total revenues received by the different units for their participation in balancing services markets.
- **Balancing market costs** are the different costs associated with the provision of balancing services. This includes direct costs, as well as opportunity costs of reservation if applicable.
- **Net balancing revenues** are the additional revenues earned by the different technologies for the provision of balancing services compared to the commodity revenues on energy markets (inframarginal rents).

The net balancing revenues are calculated by subtracting balancing market costs to gross balancing revenues.

In the next two sections, we first detail our methodology and results for the calculation of gross balancing revenues, and then present our methodology and results for the calculation of net balancing revenues.

When corrected by historical installed capacity, our results show that OCGTs earn the highest gross balancing revenues per kW



Source: Compass Lexecon analysis based on Elia data.

- **Using the installed capacity data, we computed the yearly gross balancing revenue per kW** of installed capacity for each technology
  - For more accurate results, we used a monthly extrapolation across years to capture installed capacity evolutions every month.
- **When corrected for installed capacity, OCGTs earn the highest gross revenues per kW,** driven by high revenues split equally across reservation and activation – at around 170 €/kW/year
- **Storage units also earn high revenues per kW**, in particular in FCR, since their total revenues is spread across still limited installed capacity, reaching >50 €/kW/year.
- As **CCGTs have a larger installed capacity, their revenues per kW are smaller** – reaching 30 €/kW/year.

We obtain net balancing revenues by subtracting reservation and activation costs from gross revenues

Net balancing revenue = Net reservation revenues + Net activation revenues

Net balancing revenue = Gross reservation revenue − Direct costs of reservation − Opportunity costs of reservation + Gross activation revenue − Direct costs of activation

The quantitative analysis aims to test the arbitrage between energy and balancing markets

*We use the Zeebrugge Gas Hub price to calculate the gas SRMC

We obtain net balancing revenues by subtracting reservation and activation costs from gross revenues – direct costs of reservation

Net balancing revenue = Gross reservation revenue − (1) Direct costs of reservation − Opportunity costs of reservation + Gross activation revenue − Direct costs of activation

Thermal Technologies
- Start-up costs
- Running at Pmin at a loss on DA

Batteries and Hydro PSP
- 0 direct costs of reservation

DSRs
- 0 direct costs of reservation

We assume that only thermal technologies have a direct cost for reservation in the case where they have to specifically start and run for the service provision.

We assume that there is no specific start-up cost for FCR. For mFRR Up, we assume that only CCGTs have a reservation cost, as OCGTs and CHPs can react more quickly if activated.

We obtain net balancing revenues by subtracting reservation and activation costs from gross revenues – opportunity costs of reservation

Net balancing revenue = Gross reservation revenue − Direct costs of reservation − (2) Opportunity costs of reservation + Gross activation revenue − Direct costs of activation

Thermal Technologies

CSS if CSS > 0 for Up reservation

Batteries and Hydro PSP

DA price volatility

Or

ID price volatility

DSRs

0 MC

- We assume that **DSR** has no opportunity cost of reservation.
- For **thermal units**, we assume that the Clean Spark Spread is the opportunity cost when it is positive for **upward reservation**.
- For **downward reservation**, we assume that the opportunity cost is 0 when the CSS is positive, but equivalent to the CSS when CSS is negative. However, since DA losses at negative CSS are already considered in the direct costs, we do not subtract them again as opportunity costs.

We obtain net balancing revenues by subtracting reservation and activation costs from gross revenues – direct costs of activation

Net balancing revenue = Gross reservation revenue − Direct costs of reservation − Opportunity costs of reservation + Gross activation revenue − Direct costs of activation (3)

Thermal Technologies
- Fuel & CO_2 costs for up activation
- Avoided fuel & CO_2 costs for down activation
- Start-up costs

For OCGTs and CHPs, for mFRR only

Batteries and Hydro PSP
- Optimised charge/discharge at Min/Max DA price

DSRs
- DA price for down activation
- Loss of consumption/ production if up activation

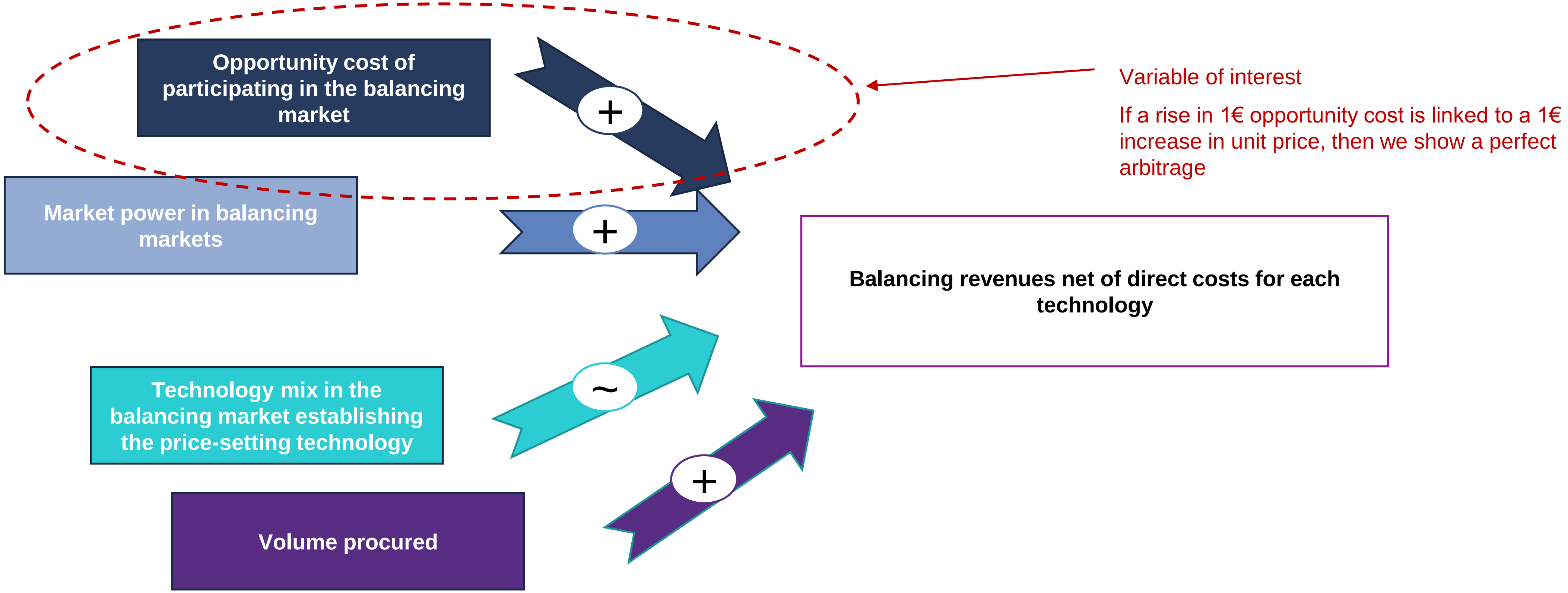
Proxied using bid data (not disclosed publicly for confidentiality reasons)

*We use the Zeebrugge Gas Hub price to calculate the gas SRMC

3.

Overview of econometric analysis

Reservation revenues – We conducted an econometric analysis to test whether there is a perfect arbitrage between balancing and energy markets



Reservation revenues - Proposed econometric methodology to test the effect of opportunity costs on balancing revenues

We ran the following general model framework to test the how the opportunity costs is translated into balancing revenues

1 **We calculate our revenue variable, accounting for direct costs to only capture the revenue part influenced by the opportunity cost, expressed in (€/MW)**

$$UnitpriceReservation_{m,t,d} = \frac{Balancing\ market\ revenue_{m,t,d} - Reservation\ Direct\ costs_{m,t,d}}{Volume\ Reserved_{\ m,t,d}}$$

2 **We run the regressions to test the impact of the opportunity costs on the reservation revenues (net of direct costs)**

$$UnitpriceReservation_{m,t,d} = \beta_0 + \beta_1 OppCostDriver_{t,d} + \beta_2 TechnologyMix_{m,d} + \beta_3 Marketpower_{m,d} + \beta_3 TotalVolumeProcured_{m,d} + u_{m,d}$$

t = technology

m = balancing market, or set of markets (reservation only)

d = CCTU

$\boldsymbol{OppCostDriver}$ = *Day ahead prices, Clean Spark Spread, volatility indicators if storage/ hydro*

$\boldsymbol{TechnologyMix}$ = *% of the different participating technologies in the market for each period (several variables needed)*

$\boldsymbol{Marketpower}$ = *market power variable (HHI or RSI) for the balancing market (or multiple if set of markets)*

$\boldsymbol{TotalVolumeProcured_{m,d}}$ = *the total volume procured for a given period.*

Our econometric analysis shows that opportunity costs influence captured prices, but to different extents across markets and technologies

Across most technologies and markets, our econometric analysis shows a statistically significant effect of opportunity costs on captured prices in balancing markets

- We find that for **mFRR reservation**, **the opportunity costs of the different technologies only explain small variations in unit prices** – indicating that the different technologies do make net revenues on this market
- In **aFRR, results for storage assets show that a 1€ increase in daily price spreads is linked to larger-to-1 increases in captured revenues** – which can be explained by reservoirs being larger than 1 MWh, multiplying the cost of being reserved
- In **aFRR, thermal technologies show closer relationships between opportunity costs and captured revenues**, indicating a closer arbitrage relationship, particularly for CCGTs.

Our econometric results are stable across the model specifications tested, but a large share of the variations in captured prices remains unexplained

- **The goodness of fit of our OLS models is usually around 0.2-0.6** depending on the market and technology, but can be around 0.05 in some cases (for example for CCGTs/storage in FCR, or OCGTs in aFRR)
- **In most cases though, the coefficients are stable across Tobit/OLS specifications** and exhibit limited fluctuation with the addition of control variables.

Result illustration – in the aFRR market, the clean spark spread of CCGTs is linked to a variation in aFRR prices

aFRR reservation unit price (Up+Down)	OLS	OLS	OLS	Tobit	Tobit	Tobit
1[CSS>0] × CSS	**0.727*** **	**0.762*** **	**0.474*** **	**0.748*** **	**0.852*** **	**0.474*** **
1[CSS<0] × CSS	**-2.111*** **	**-2.007*** **	**-1.886*** **	**-2.174*** **	**-2.045*** **	**-1.886*** **
aFRR volume control		Yes	Yes		Yes	Yes
RSI control		Yes	Yes		Yes	Yes
Technology mix control			Yes			Yes
Constant	1,116***	-161.2***	1,578*	1,056***	-2,358***	1,578*
Observations	1,095	1,094	1,002	1,095	1,094	1,002
R-squared	0.527	0.567	0.559	N/A	N/A	N/A

Note: aFRR is carried out on daily data to reflect daily block bids which are more prevalent in aFRR. aFRR Up and Down markets are considered jointly as participants may split their opportunity costs across markets.

Importantly, the fact that we do not observe an improvement in R2 when adding technology share data suggests that they do not add information that is not already contained in other controls. It seems plausible that the share of other technologies is a function of CCGT's CSS, implying that controlling for it absorbs part of the effect that should in fact be ascribed to the CSS.

Overall, our results indicate that there is a net revenue beyond the opportunity cost for the different technologies

Our econometric analysis generally does not find a perfect 1-to-1 arbitrage between generating revenues on energy markets and balancing markets across the technologies studied (although it is close to 1 for some technologies)

Different factors could play out to set the final unit price of the different technologies: market power, merit order effects, etc. which impact the revenues of the technologies in the balancing market. The lower explanatory power in some of our models imply that other factors influence the final unit price beyond the factors we have accounted for.

As a result, **our results highlight the possibility for the different technologies to earn a net revenue** beyond their opportunity cost

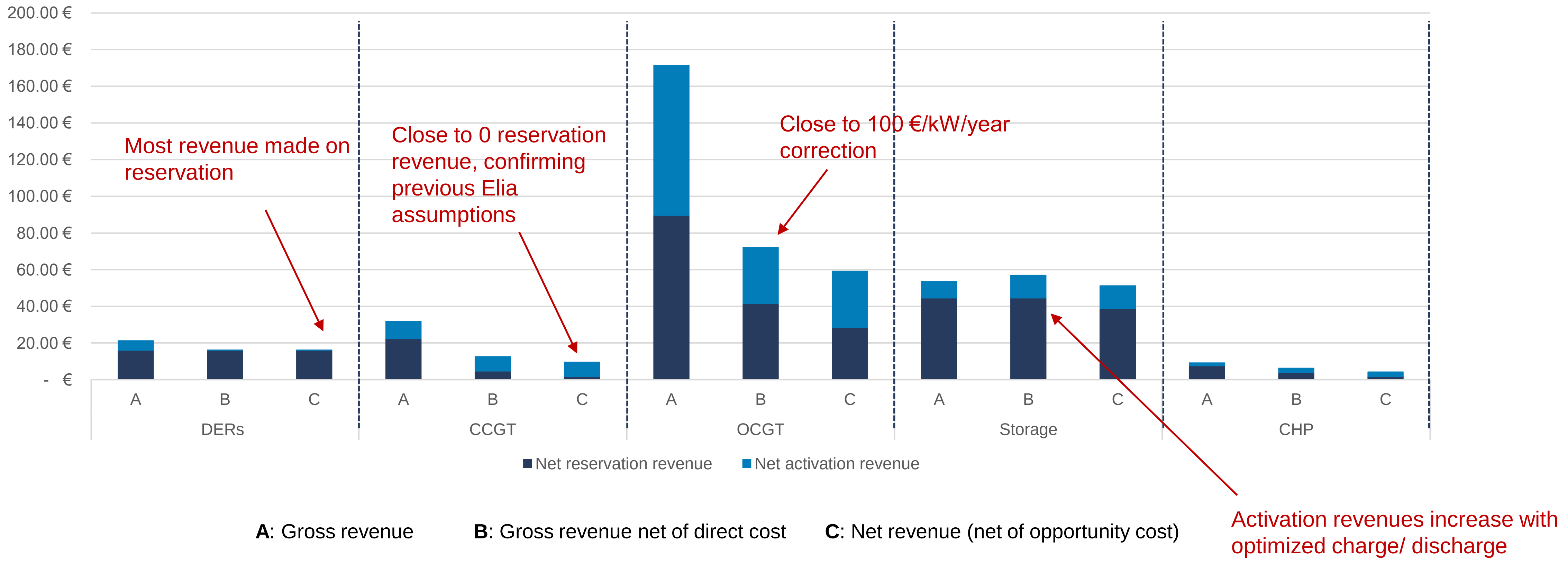
Therefore, we subtract the opportunity costs calculated to the gross revenues net of direct costs to find the net revenues across technologies.

4.

Net revenue results and crisis adjustment

Correcting the balancing market revenues by the opportunity costs of OCGTs and CCGTs reduce their net balancing revenues significantly

Average annual balancing revenue per kW of installed capacity [€/kW/year] – gross and net revenues



A: Gross revenue **B**: Gross revenue net of direct cost **C**: Net revenue (net of opportunity cost)

A large share of net revenues can be explained by revenues earned in activation, which was not accounted for previously

The key question on the net revenue analysis remains their future validity, particularly in a post-crisis market setting

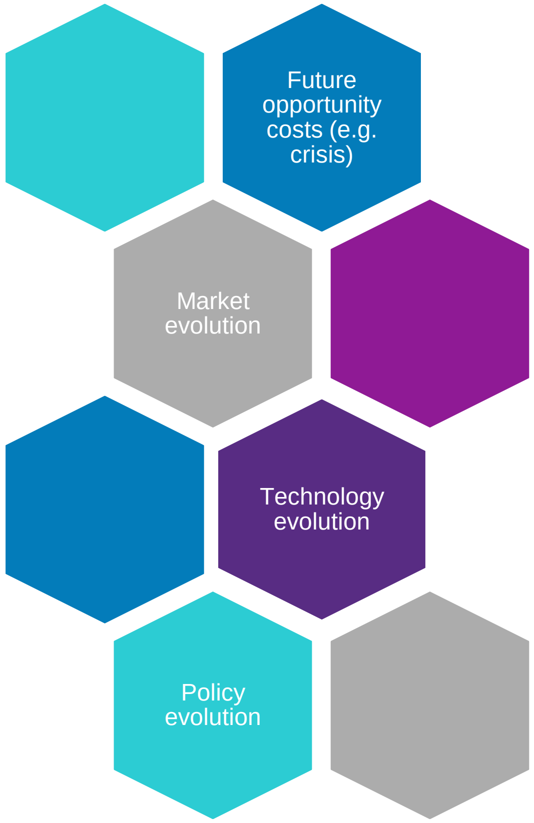
One of the important questions for setting the CRM parameters is to what extent historical analysis help us foresee future net revenues,

- **This is particularly the case with the crisis affecting past revenue data** – although it is also uncertain to assert that revenues will come back to their pre-crisis levels
  - **As we remove opportunity costs directly from revenues**, such as day-ahead price volatility or clean spark spread, **we control to some extent for the high revenues earned during the crisis** because these costs rose as well.
  - However, merit order effects could lead to higher revenues for inframarginal technologies on balancing markets during the crisis period

- **In its previous methodology, Elia corrected its net revenue estimations** with future FCR price convergence assumptions (60% for batteries) and future competitive pressure in mFRR (70% for DSR).

- **Different methods could be used to adapt net balancing revenues to these future evolutions, if applicable**
  - Accounting for the effect of the crisis could be carried out by filtering extreme events, or correcting by the crisis effect on average for instance.
  - For the crisis, corrections applied should account for the fact that although revenues increased, costs also increased during the period.

Possible future factors impacting future net balancing revenues

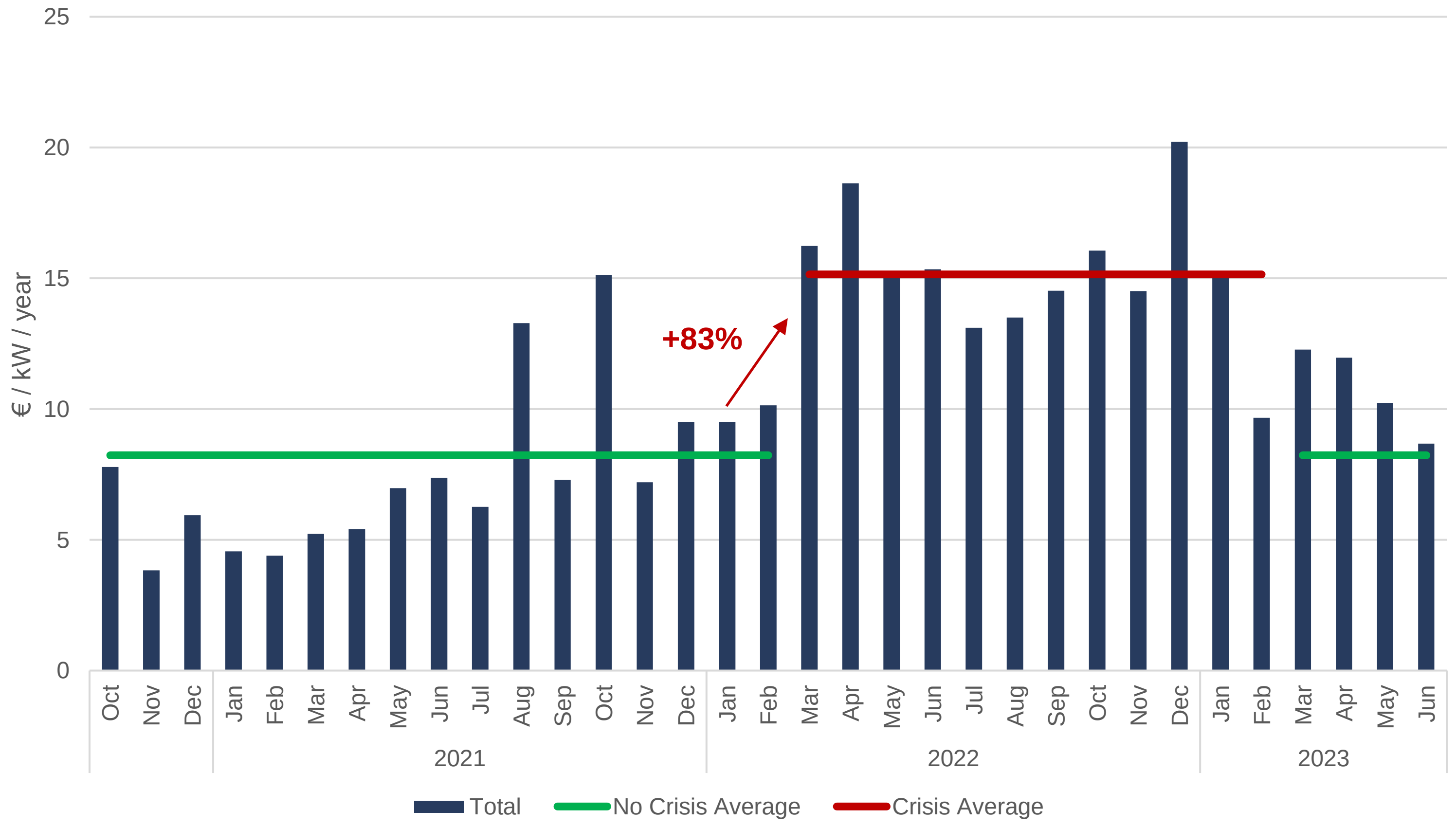


Across all technologies, there was a marked increase in revenues per kW during the crisis

There were higher net revenues observed during the second part of the crisis

- **There was a marked increase in net revenues across all technologies from Q2 2022** (+83% between the two average total revenues)
- **Interestingly, this increase happened after the September 2021 crisis**. This can be traced back to two factors:
  - Costs were also higher during the crisis, with higher gas prices and opportunity costs to participate in the balancing markets
  - OCGTs made significant revenues in the later part of 2022, which drove up the numbers in that period
- All in all, **correcting for the period of higher net revenues during the energy crisis would allow a better view of future revenues** for the different technologies

Annualized net balancing revenues per kW of installed capacity (Jul 2020 - Jun 2023)



We have tried different methods to control for the crisis, as the period of increased revenues can be different across technologies

Common crisis period

- We have used the overall revenue graph shown on the previous slide to define the **crisis period between March 2022 to February 2023** – 12 months are flagged as the crisis period in total

Market specific 1

- Alternatively, to account for the crisis effect hitting the various balancing markets at different points in time, we define a **market specific** approach. In each reservation and activation submarket, we define the **12-month period with the highest observed net revenues** as the crisis period.

Market specific 2

Market specific 3

- We explore sensitivities to the market specific approach. In a second version the various **aFRR submarkets are aggregated** to find a single 12-month period with the highest net revenues for aFRR, whereas a **third version considers the same adjustment for mFRR**.

Data driven approach

- Finally, we deploy a **data driven approach** to identify outlier months. This approach is **technology specific**, as it allows to identify, for each technology, which months of exceptional revenues to flag as the crisis
- The identification of outliers is based on a **1-sigma range**.

We have used these 4 approaches in parallel to calculate correction coefficients for the crisis

Note: The “market specific 2/3” methods are considered to guarantee that the identified crisis periods in “market specific 1” are not skewed due to the apportionment of must-run and startup costs of thermal units to specific markets.

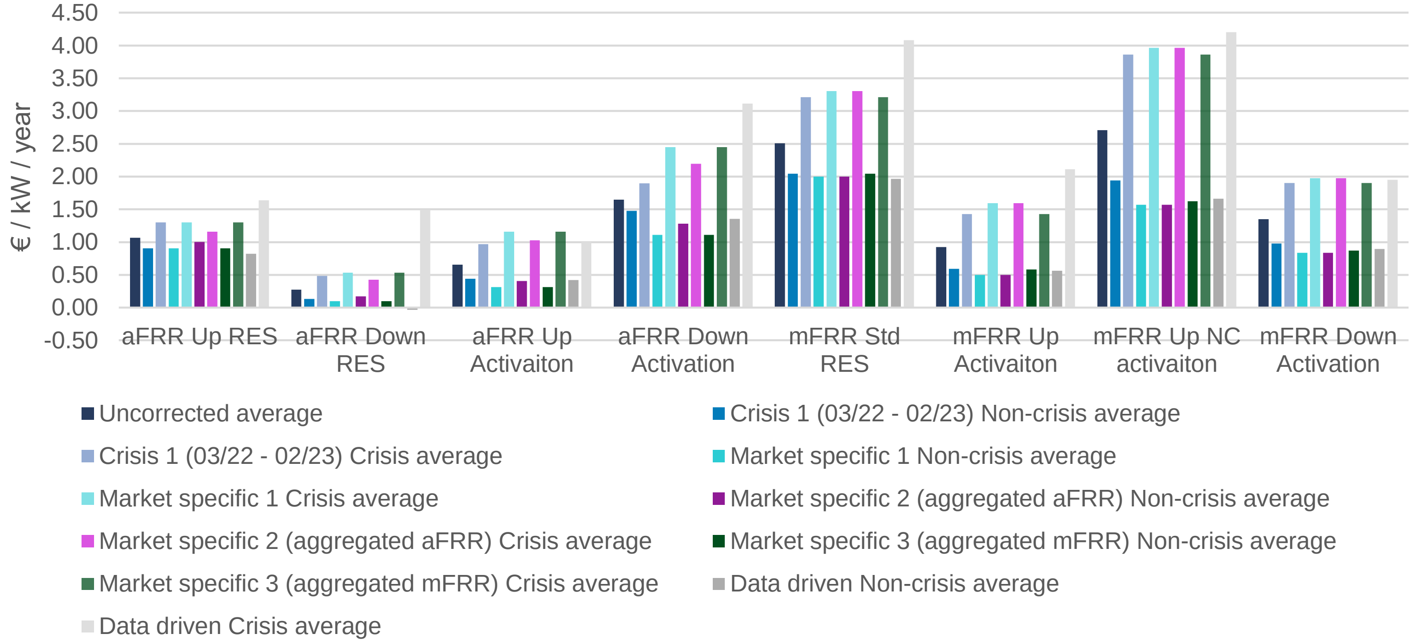
Average net revenues in submarkets differ between the crisis and non-crisis periods, but are fairly stable across methodologies

Crisis effects differ across markets, which leads to market-specific correction factors

- **Some markets show a large gap between their average net revenues in the crisis or non-crisis period**, such as aFRR Up activation and mFRR Up activation
- **Others show more modest increases,** such as aFRR Up reservation or aFRR Down activation
- From these differences in mean revenues**, we derive correction coefficients** which we can apply to crisis months in each approach, to account for the crisis effect

This could plead for a market-specific approach to correcting for crisis revenues, rather than setting a bulk period across markets

Average net revenues in the crisis vs. non-crisis period across methodologies

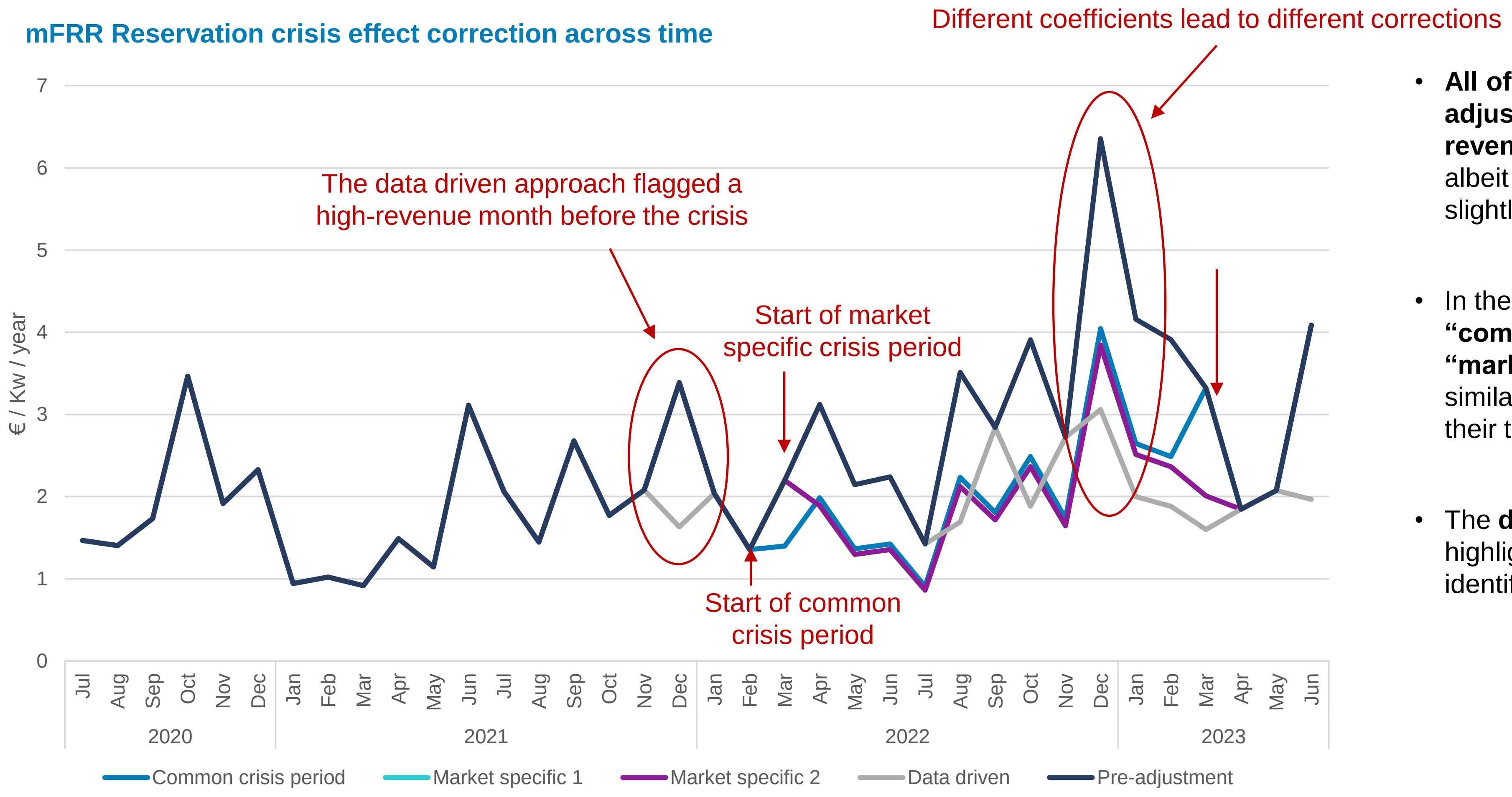


Corresponding coefficients to correct for the crisis average revenue difference

	FCR	aFRR Up RES	aFRR Down RES	aFRR Up ACT	aFRR Down ACT	mFRR Std RES	mFRR Up ACT	mFRR Up NC ACT	mFRR Down ACT
Crisis period	1.00	0.70	0.28	0.46	0.78	0.64	0.41	0.50	0.51
Market specific 1	0.73	0.70	0.18	0.27	0.45	0.60	0.31	0.40	0.42
Market specific 2	0.73	0.86	0.41	0.39	0.58	0.60	0.31	0.40	0.42
Data driven	0.89	0.50	0.00	0.42	0.43	0.48	0.27	0.40	0.46

Zoom on mFRR Std reservation correction to account for the crisis effect in each methodology

mFRR Reservation crisis effect correction across time

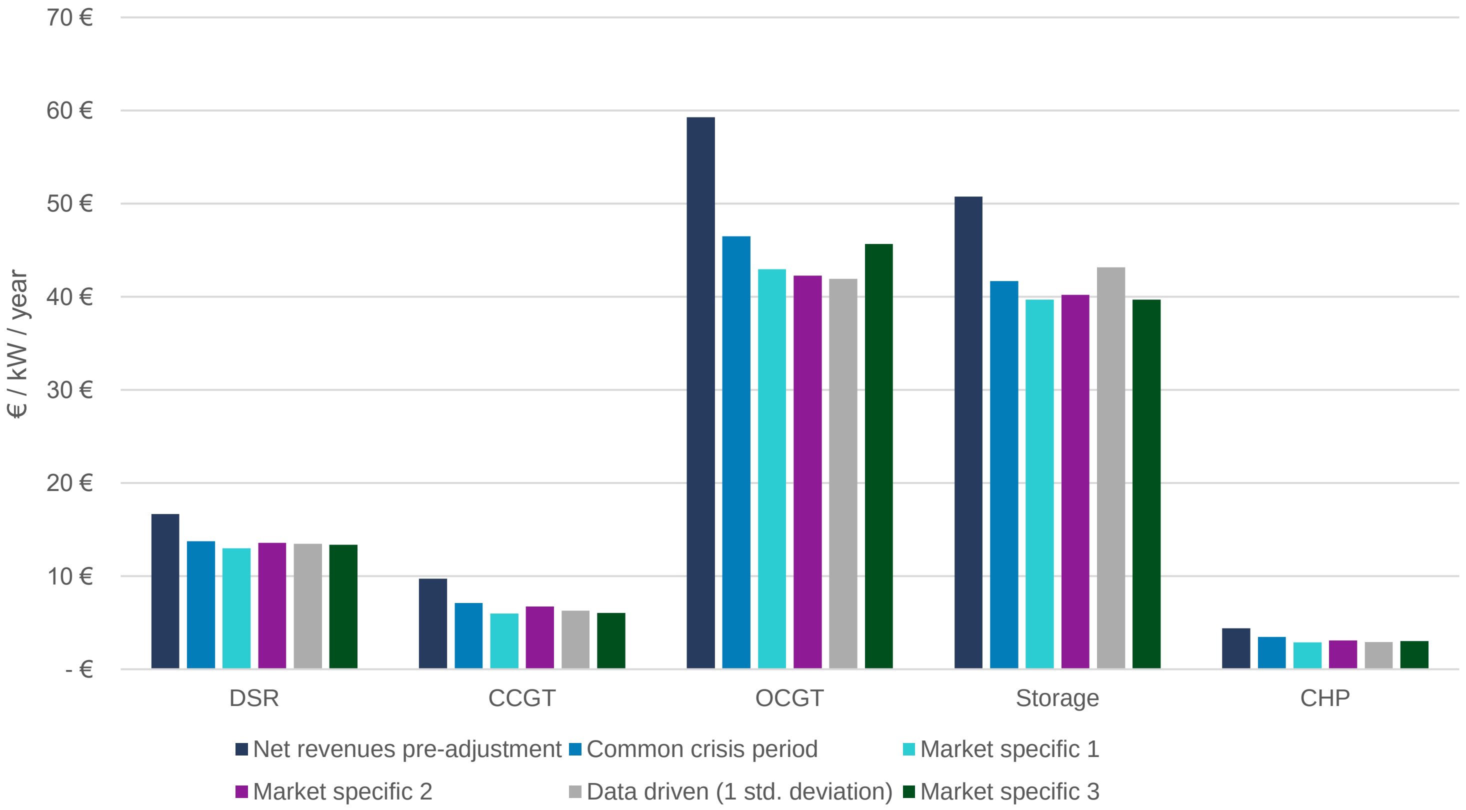


- **All of the deployed crisis adjustment methods reduce net revenues during the crisis period,** albeit to a varying extent and at a slightly varying point in time
- In the case of mFRR reservation the **"common crisis period" and "market specific" methods** yield similar results, only slightly varying in their timeframe
- The **data driven approach** also highlights anomalies outside of the identified crisis periods

Note: Approaches "market specific 1" and "market specific 2" only differ for aFRR, but are equivalent for mFRR.

Correcting for the crisis impact brings down net revenues across all technologies, but especially for OCGTs and Storage

Net balancing revenues post crisis adjustment by technologies (€/kW/year)



- **Net revenues are fairly stable across the different crisis adjustment methods**
- **Overall, the correction factors reduce total net revenues** by:
  - 18-22% for DSR
  - 27-38% for CCGT
  - 22-29% for OCGT
  - 15-22% for Storage
  - 21-34% for CHPs
- **In absolute terms, the by far largest adjustment concerns OCGTs (ca. 17 €/kW/year) followed by storage (ca. 10 €/kW/year)**
- Still, crisis-adjustment revenues for OCGT and storage remain higher than expected and **may require further adjustments to reflect future earning potentials**

Correcting for expected future FCR price convergence leads to a decrease in FCR revenues for storage, depending on the FCR target price

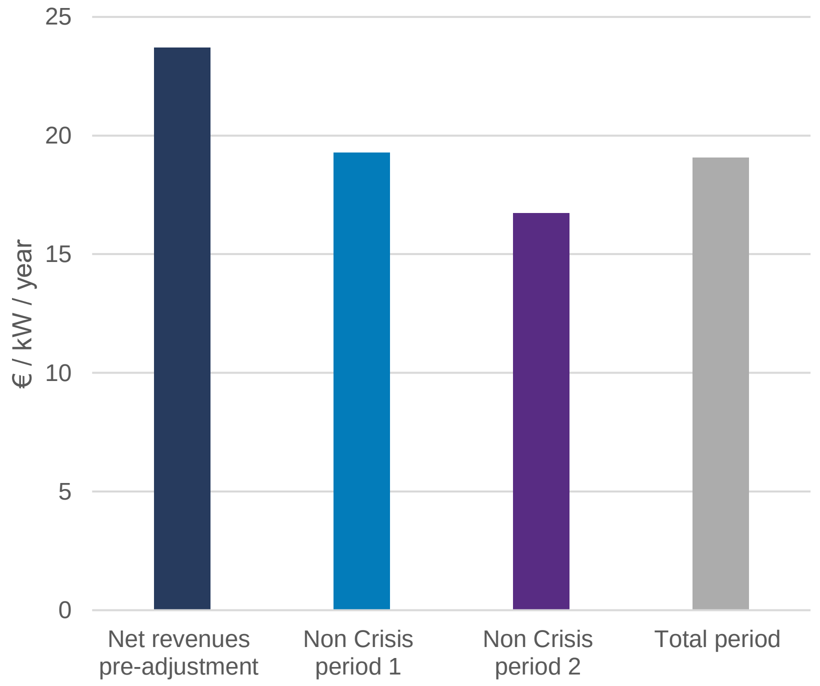
We also can correct FCR revenues to account for the expected future convergence of prices with Germany.

- We assume that this convergence will gradually occur **starting in 2025 towards 2028**, reaching full convergence then
- Here, the correction coefficients can take different values **depending on the expected price towards which FCR prices start converging**
- We calculate **three correction coefficients** based on the difference between Belgium average FCR prices over the 2020-2023 period, compared to different German average prices
- From this, we can correct FCR net revenues for storage and CCGTs, for which **assuming a gradual convergence towards pre-Sept 2021 prices lead to biggest effect on net revenues**

FCR average prices in Germany and Belgium, by period

		DE average	BE average
Crisis 1 (04/22)	*Non-crisis average*	18.28	34.92
	Crisis average	21.87	27.84
Crisis 2 (09/21)	*Non-crisis average*	11.98	29.63
	Crisis average	23.20	32.67
Total	*Total period*	17.72	29.09

Storage FCR net revenues pre and post FCR adjustments comparison



The revenue adjustments for FCR link back to the question of defining the crisis period. Consistency in the definition could be desirable, but a technology/market specific approach could also be defended.

Installed capacity in Belgium is expected to evolve in the coming years, which will affect future revenues per kW

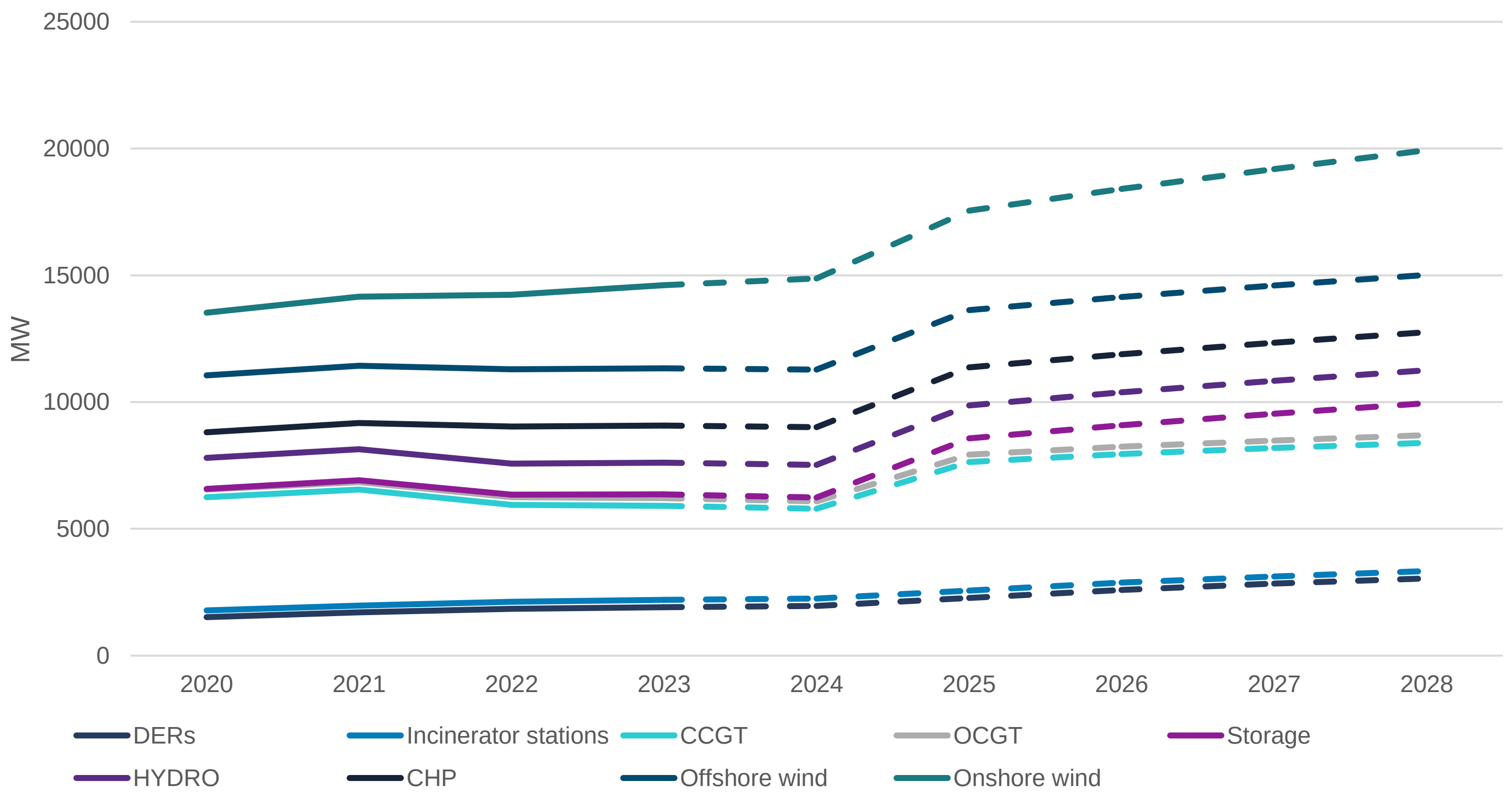
Installed capacity is expected to evolve in Belgium for some technologies

- According to Elia's simulations carried out for the latest Adequacy and Flexibility study, **by 2028 installed capacity will increase** particularly for:
- DERs: +1135 MW
- Storage: +1109 MW
- Onshore wind: +1650 MW
- CCGTs: +1350 MW

Our net revenues should be adjusted to reflect these capacity evolutions

- Because **net revenues are expressed in revenue per capacity terms**, these evolutions will need to be reflected in the calculations
- **We should therefore correct our net revenues with coefficients** reflecting the difference in capacity between 2023 and 2028

Installed capacity in Belgium, historical and forecasted – selected technologies (MW)



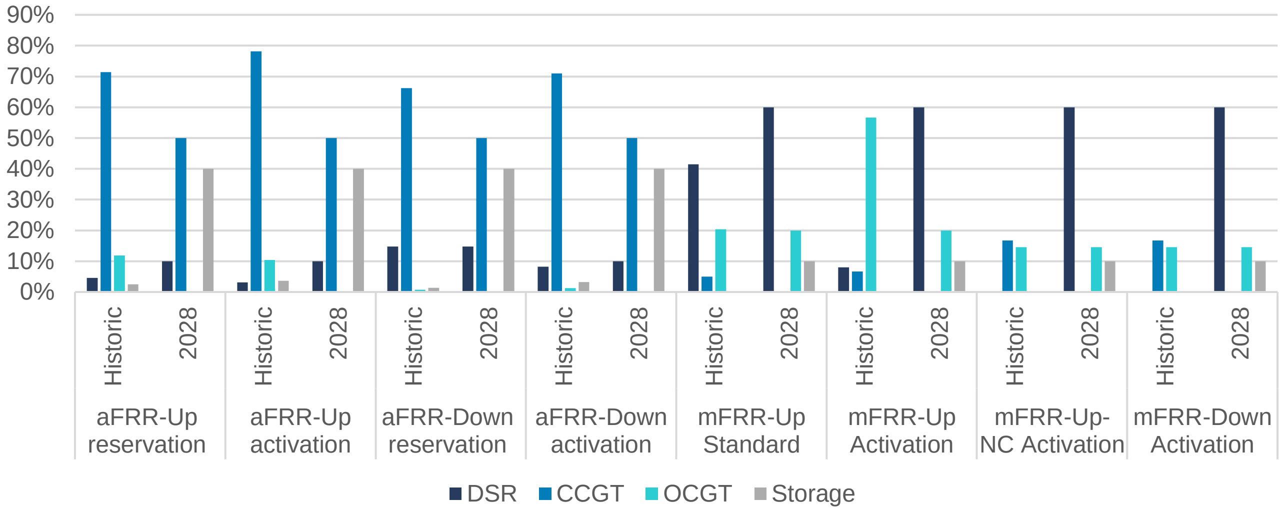
Source: Compass Lexecon using Elia Adequacy and Flexibility study data and data from Scenarios for the CRM Parameter Calculation linked to Y-1 auction for 2025-26 and Y-4 for 2028-29.

The mix of technologies providing balancing services will shift, with DSR and Storage taking over a substantial share of volumes

- Substantial capacity expansions will mean that a large fraction of balancing volumes in the future will be provided by storage and DSR
- For aFRR markets, this will particularly come at the expense of CCGTs currently providing a large share of these volumes
- In mFRR, particularly OCGTs will be affected by this development.

We use the ratio between the historic market share of a technology and its 2028 expected share (estimated by Elia) to calculate adjustment factors that we apply to historic revenues. Although the merit order effect is likely to reduce revenues, it could not be taken into account.

Historic (2020-23) and expected 2028 technology mix by market [%]



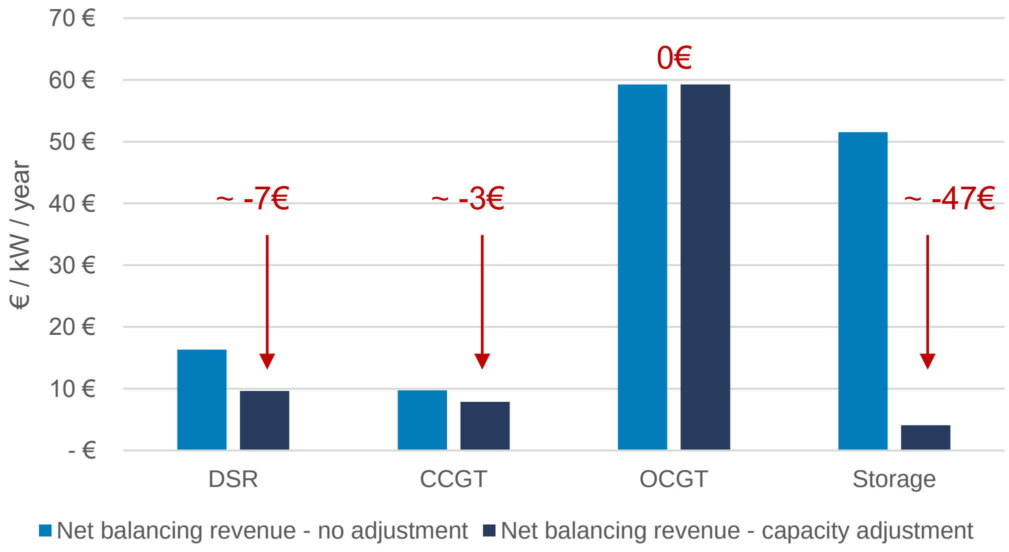
2028 technology mix adjustment coefficients

	FCR	aFRR-Up reservation	aFRR-Up activation	aFRR-Down reservation	aFRR-Down activation	mFRR-Up Standard res.	mFRR-Up Activation	mFRR-Up-NC Activation	mFRR-Down Activation
DERs	0.00	2.18	3.26	1.00	1.22	1.45	7.51	-	-
CCGT	0.00	0.70	0.64	0.76	0.70	0.00	0.00	0.00	0.00
OCGT	0.00	0.00	0.00	0.00	0.00	0.98	0.35	1.00	1.00
Storage	1.00	15.84	11.19	31.07	12.44	-	-	-	-

While expanding capacity pushes down per kW revenues of Storage and DSR, their expected rising volume share works in the opposite direction

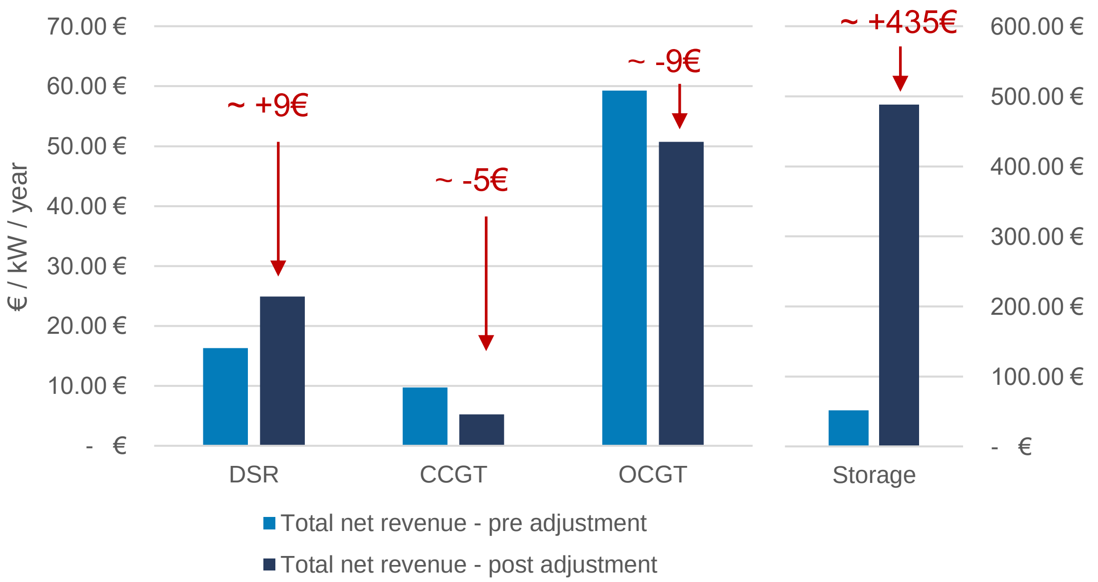
Net revenues - 2028 installed capacity adjustment impact

Increasing capacity pushes down 2028 per kW revenues of CCGTs, DSR and particularly Storage.



Net revenues - 2028 technology mix adjustment impact

Rising future balancing volumes for DSR and particularly storage lead to substantially rising revenues, while gas turbines face a decline in profits.

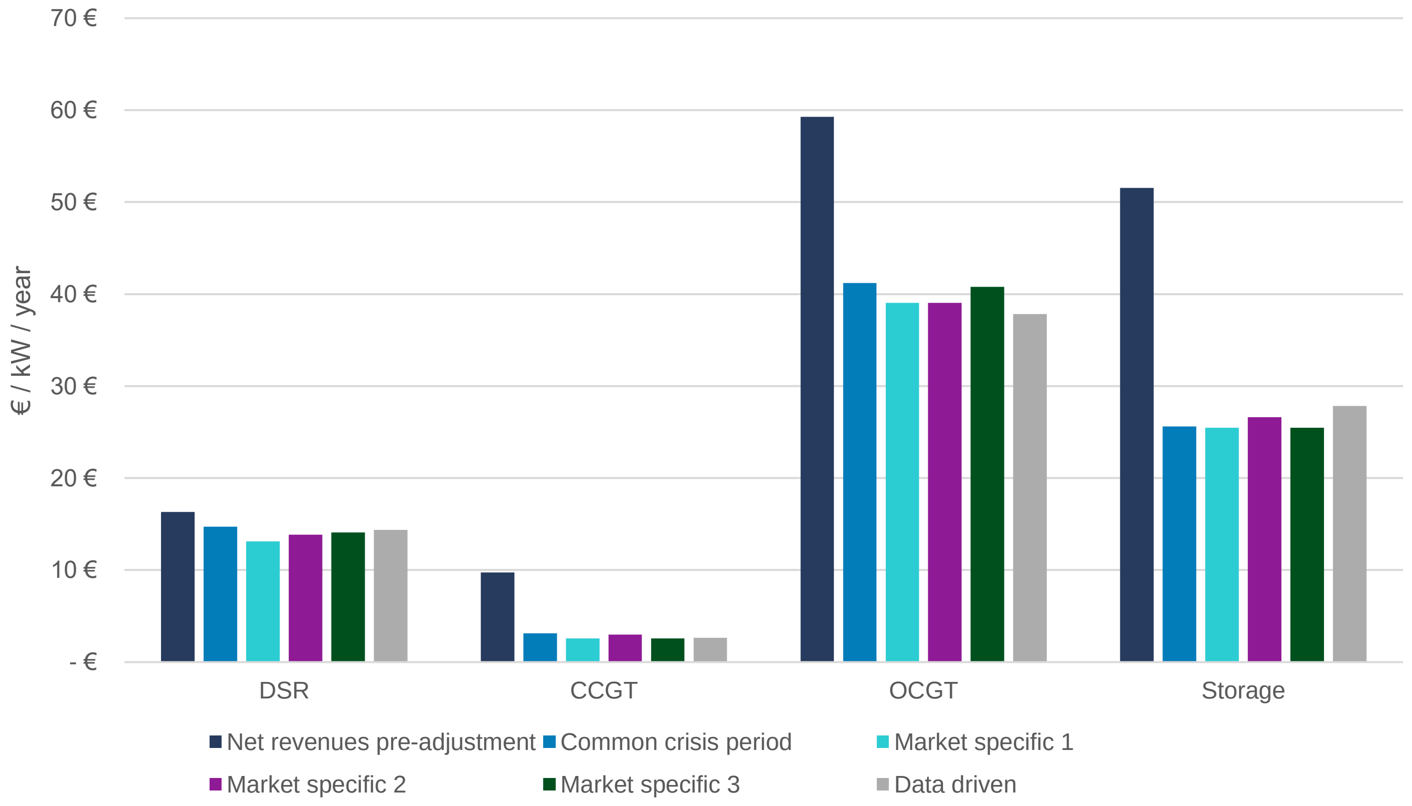


Importantly, these two graphs illustrate the effect of either adjustment in isolation. The overall effect of both adjustments on a technology is not given by the sum of the Euro values displayed above, but arises from the multiplication of the coefficients applied in the two adjustments (see next page).

Note: (i) Coefficients are here applied to pre-crisis-adjusted revenues. Their effect will likely be smaller when applied to lower, crisis-corrected revenues. (ii) The 435 €/kW/year increase for storage assumes that the entire increase in the share of storage's balancing volumes is distributed to currently existing capacities. The overall effect will be attenuated by the substantial increase in installed storage capacity.

Correcting for FCR convergence, the energy crisis and capacity as well as technology mix evolutions grants a better view of future net revenues

Net revenues adjusted for 2028 installed capacity, volume shares and FCR price convergence by crisis period adjustment [€/kW/year]

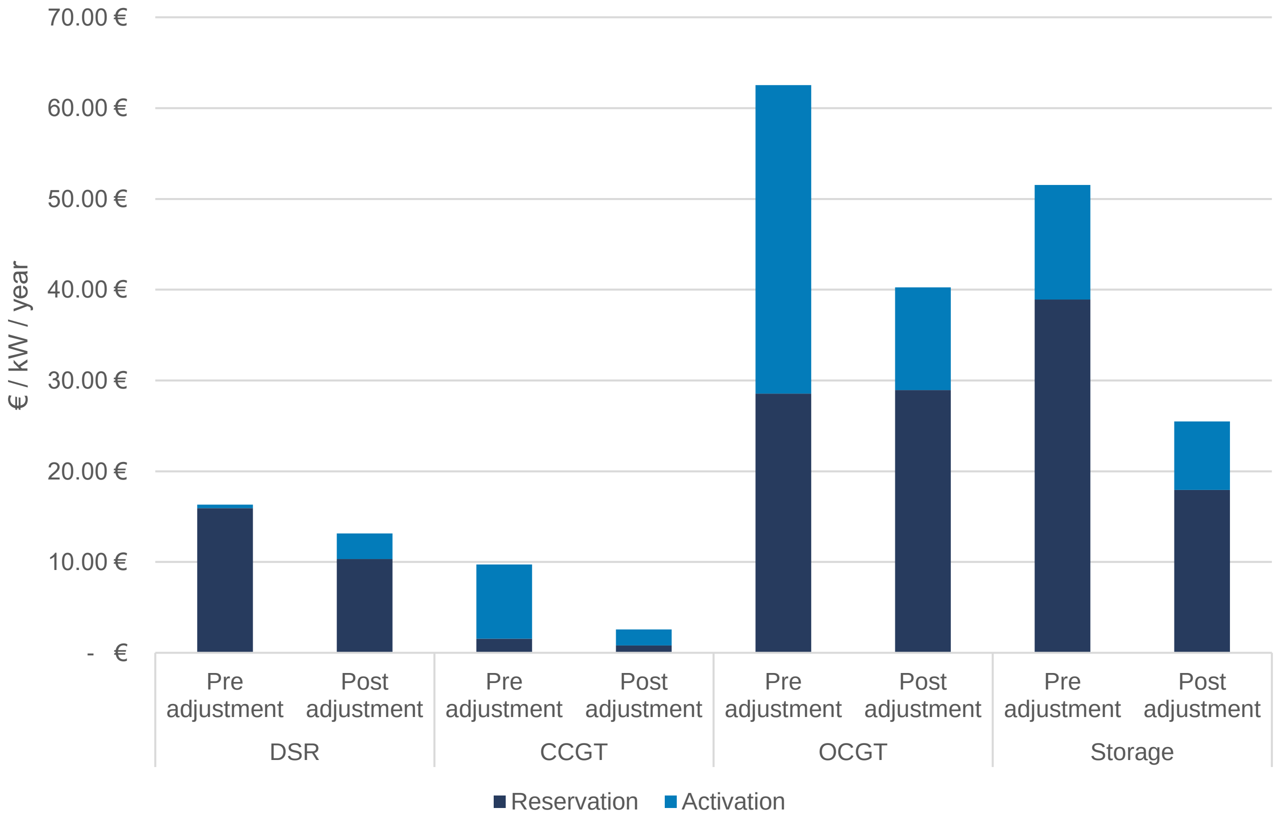


- When applying the corrections, we have **different net revenues depending on the crisis methodology**
- In absolute terms, the largest decrease compared to pre-adjustment revenues is observed for Storage (ca. 25 €/kW/year) followed by OCGTs (ca. 19 €/kW/year).
- In relative terms, the adjustments have the most substantial effect on CCGTs:
  - 71 – 76% for CCGTs
  - 30 – 36% for OCGTs
  - 10 – 20% DSR
  - 46 – 51% for Storage
- For DSR, the adjustments exhibit a very limited effect on net balancing revenues
- Interestingly, for **storage revenues change only very slightly relative to those observed after the crisis adjustment** – as FCR price convergence, capacity expansion and their rising volume share in balancing markets balance each other out

Note: It is important to note that the net revenues presented here do not include future mFRR revenues for storage. On a following slide we present a sensitivity of this result using a proxy for future mFRR earnings.

Zoom on Market specific 1 – Reservation accounts for the larger share of overall net revenues, but activation revenues are not negligible

Market specific 1 - Adjusted net revenues by activation and reservation [€/kW/year]



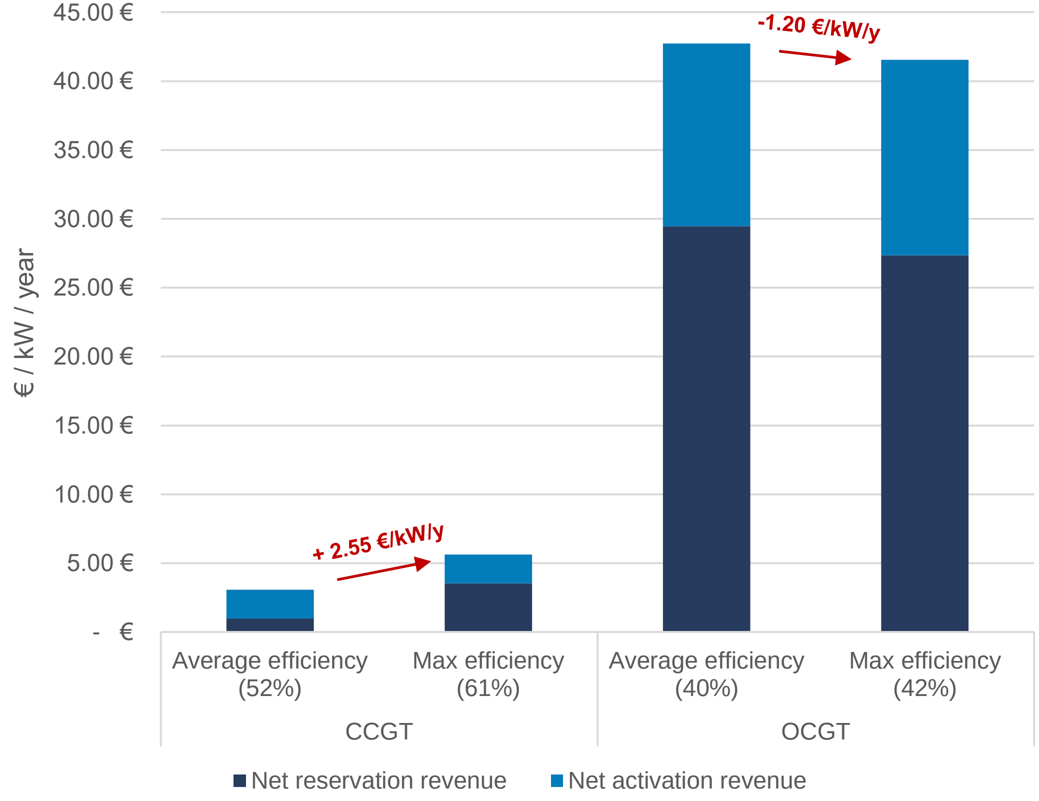
- Under the market specific 1 crisis adjustment, the **share of profits originating from reservation is around three quarters for DSR, OCGT and storage** – ranging from 70-78% among these three technologies.
- For CCGTs this share is substantially smaller (ca. 30%), however starting from a small level of overall revenues as a basis
- In absolute terms, **activation revenues for OCGTs lie around 11 €/kW/year** – amounting to several times total CCGT revenues and not far off of overall DSR revenues.

While reservation revenues tend to be the main source of balancing profits, neglecting activation might entail an underestimation of their magnitude

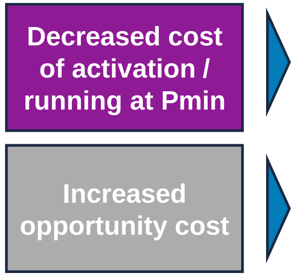
Note: It is important to note that the net revenues presented here do not include future mFRR revenues for storage. On a following slide we present a sensitivity of this result using a proxy for future mFRR earnings.

Gas Turbines – New higher efficiency CCGTs earn slightly increased adjusted net balancing revenues, but the same does not hold for OCGTs

Annual net balancing revenues per kW of installed capacity at average and max. efficiency of Belgian CCGTs / OCGTs



- We test how revenues of new built thermal units measure up against existing ones, by **comparing the highest efficiency plant coming online by 2028 to the average of currently running units.**
  - 61% vs. 52% for CCGTs
  - 42% vs. 40% for OCGTs
- A higher efficiency decreases SRMC (increases CSS), which yields **two counteracting effects.**



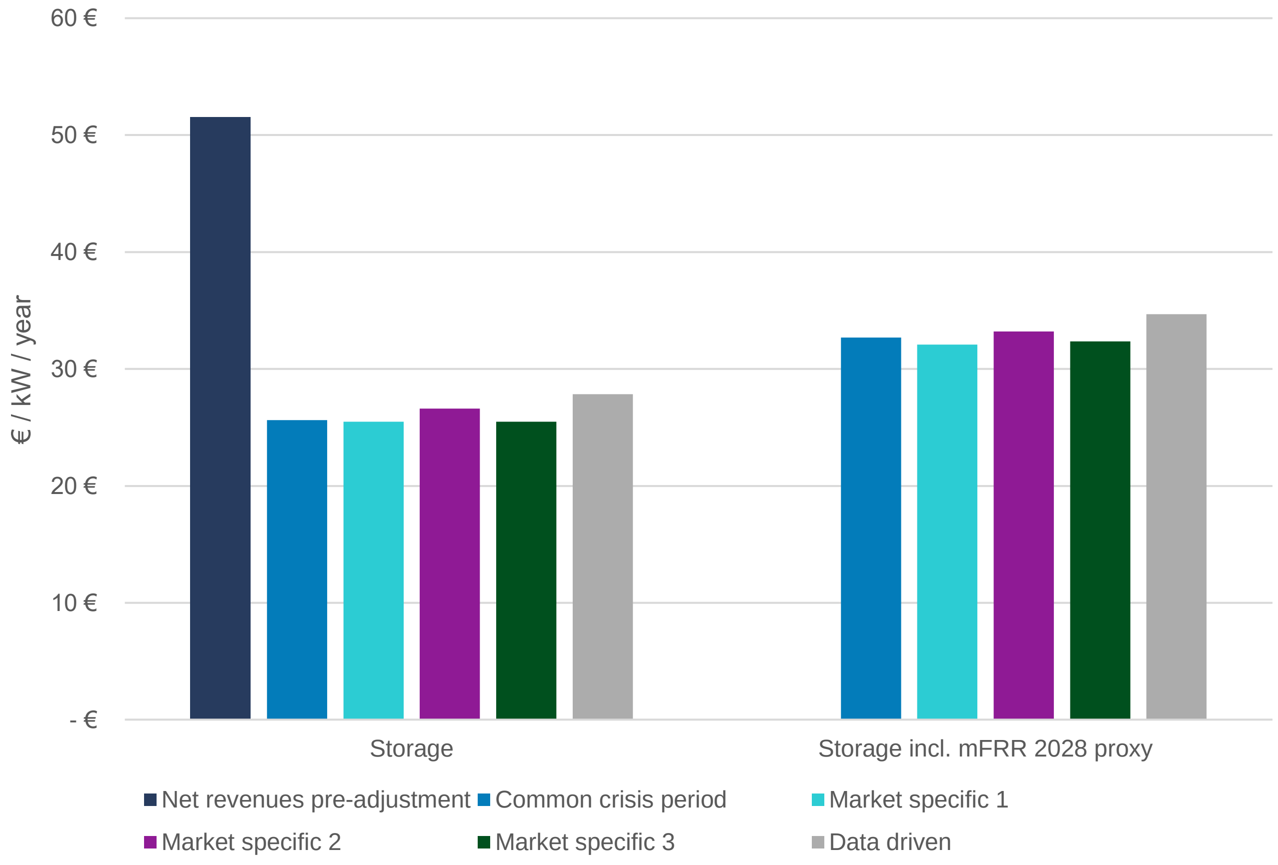
- Lower SRMC increases activation revenues
- Decreased DA losses for running at CSS<0
- More CCTUs with opportunity cost (CSS>0)
- Higher opportunity cost in CCTUs with CSS>0

- Maximum efficiency net revenues **increase by 2.55 €/kW/year for CCGTs, but slightly decrease by 1.20 €/kW/year for OCGTs.**
- OCGT revenues decrease, as a higher efficiency implies higher opportunity costs of participating in reservation markets.
- The same applies to CCGTs, however they also benefit from a decrease in costs whenever they run at a loss in the DA market in order to be reserved for aFRR and mFRR – which outweighs the opportunity costs.

Note: Average efficiency refers to the capacity weighted average of efficiency of existing units and is the level used in previous calculations. Maximum efficiency considers all volumes to be provided by the highest efficiency plant in existence by 2028 according to ELIA's adequacy and flexibility study.

Including a proxy for the future mFRR earnings potential of storage increases net revenues, but they remain below pre-adjustment revenues

Adjusted net revenues – sensitivity for storage using a proxy for future mFRR revenues [€/kW/year]



- Elia thinks **storage might participate in mFRR** to a limited extent by 2028.
- Since, there has been no participation of storage in mFRR in the past, the future earnings cannot be based on a historical value adjusted for changes in participation share – as is the case for other technologies.
- Instead, **we proxy storage mFRR revenues using historical (2020-23) average mFRR prices** and adjust them for the expected share of storage in mFRR markets (10%), a crisis period coefficient, the roundtrip efficiency of a battery and the installed storage capacity in 2028.
- The resulting mFRR **revenues amount to roughly 7 €/kW/year.**

Participation in mFRR will lead to a non-negligible increase in storage revenues, but the magnitude could be contained relative to revenues from FCR and aFRR markets.

There could be other adjustments to net revenues in order to better reflect future expected revenues for each technology

These could also affect future revenues for each technologies in the CRM

Merit order price effects in markets due to technology share evolutions

- The observed **shift in technology mix will most likely also affect prices due to a merit order effect** and the entry of cheaper technologies.
- This effect is only **partially considered in the context of this study** – through the correction of FCR revenues due to price convergence with Germany.
- As a result, further adjustments to the revenues, in particular for aFRR and mFRR, might be necessary, although difficult to assess.

Future evolutions of balancing markets

- **Potential market design changes** (e.g. Elia partial procurement in mFRR reservation) could also affect future revenues.
- **Future market dynamics**, as well as **volume/price evolutions.**
- **Elia's connection to the European balancing platforms** will additionally affect activation revenues, but is particularly hard to quantify (see following pages).

European balancing platforms will improve overall system efficiency, but the effect on the revenues of Belgian BSPs is unclear ex ante

- The European Electricity Balancing Guideline envisages the **connection of European markets** to cross-border balancing platforms during the years ahead
- The platforms allow for the **cross-border activation of balancing energy** based on a common merit order list

PICASSO	Platform for the exchange of **aFRR** balancing energy
MARI	Platform for the exchange of **mFRR** balancing energy

- ELIA is expected to join both PICASSO and MARI in **2024**
- Capacity procurement will remain on a national level

Different effects on Belgian BSPs‘ balancing revenues need to be considered

- The integration of European balancing energy markets aims to enhance the efficiency of the European balancing system and deliver a **reduction in overall system costs across the ENTSO-E region**.
- The platforms allow Belgian BSPs to participate in other zone‘s balancing activations and vice versa, with the **net impact on Belgian BSPs‘ balancing revenues unclear a priori**.
- **Effects that need to be considered** in an assessment include:

Increased domestic competition	**Players from other countries** will enter the Belgian activation markets and **capture part of the revenues** that were previously accrued by domestic BSPs.
Merit Order effects	The use of a common merit order list will allow for the **activation of the cheapest units** and will thus **tend to decrease prices.** Still, prices may rise for countries with below average prices prior to joining the platforms.
Participation in foreign markets	Belgian BSPs will have the opportunity to **participate in foreign activations and gain additional revenues** on top of revenues from domestic activations.

Source: ENTSO-E Accession Roadmap for PICASSO and MARI (April 2023)

Belgian activation prices tend to be high, potentially implying lower balancing revenues for Belgian BSPs through European platforms

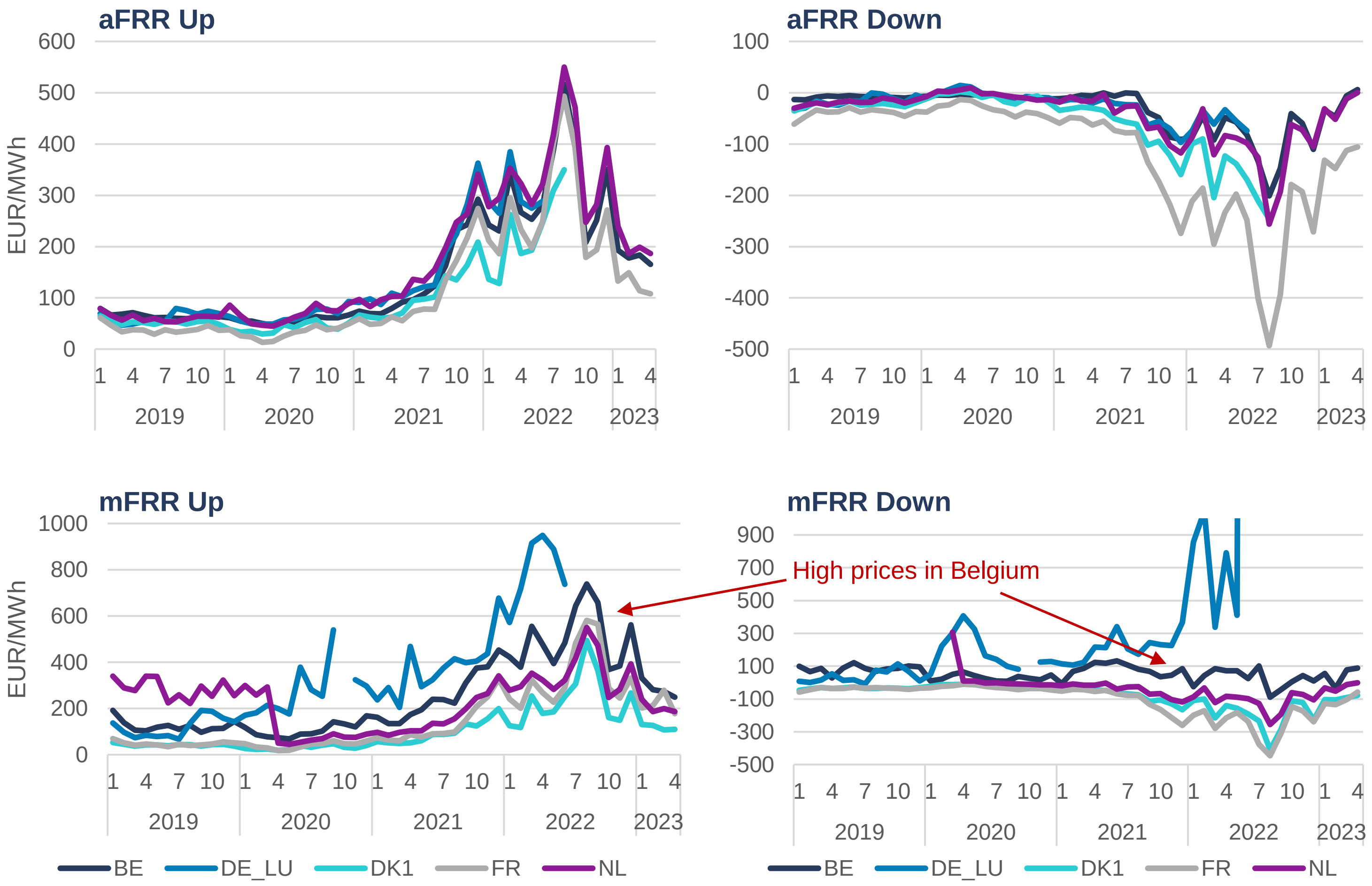
European platforms might push down historically high Belgian activation prices

- Particularly in mFRR, but also in aFRR Down, Belgian prices are historically at the higher end of the spectrum
- Connection to the European platforms might benefit Belgium through foreign players participating in the market and reducing prices
- As a result, **balancing revenues of Belgian BSPs could decrease** due to a combination of losing part of the market to foreign players and lower prices

However, several factors cast uncertainty over this development

- Impacts of European platforms will depend much more on **continuous market dynamics** than on average prices aggregated over a period of time
- **Historic prices may be based on country specific regulations** that may be adjusted when connecting to European platforms
- **In mFRR Belgian seem to be surpassed by German prices**, which might in fact imply additional revenue opportunities for some Belgian BSPs

Historical activation prices in selected countries (monthly average) [EUR/MWh]



 Source: Compass Lexecon using ENTSO-E data

Locations

Europe

Berlin
Brussels
Copenhagen
Düsseldorf
Helsinki
London
Madrid
Milan
Paris

North America

Boston
Chicago
Houston
Los Angeles
Miami
New York
Oakland
Washington, DC

Latin America

Buenos Aires
Santiago

Asia Pacific

Beijing
Singapore

6.
Annex

Gas Turbines - We subtract day ahead market losses for running at Pmin when reserved for balancing services at negative CSS

We consider the theoretical Pmin required for technology *t* to provide the reserved volume in each CCTU as

$$Pmin_{MW,t} = \frac{Reserved\ Volume_{MW,t}}{1 - \%\ Pmin_t} \times \%\ Pmin_t$$

For instance, if we observe 400 MW reserved capacity for CCGTs in mFRR Up and assuming that %Pmin = 40% this implies

$$Pmin = \frac{400}{0.6} \times 0.4 = 267 \text{ MW}$$

aFRR Up Reservation

- We subtract DA losses from reservation revenues for CCGTs, OCGTs and CHPs
- Whenever $CSS_t < 0$: DA loss = Pmin x CSS_t

aFRR Down Reservation

- To avoid double counting, we subtract DA losses for running at Pmin whenever $CSS_t < 0$ and no aFRR Upward reservation is present for technology *t*
- In addition, we subtract DA losses for running at the reserved capacity above the Pmin whenever $CSS_t < 0$.

mFRR Up Reservation

- We only subtract DA losses for CCGTs, since OCGTs are assumed to be able to start-up in time for aFRR activation
- To avoid double counting we subtract DA losses for running at Pmin whenever $CSS_t < 0$ and DA losses are not already subtracted from aFRR for the CCTU

Different factors could explain why we do not find a perfect arbitrage in some markets

Market power	• **Concentration and pivotality could grant market power to market players**, thus allowing higher margins in certain markets. • **It is not possible to wholly capture this in our model**, since variations in market power indicators might not be relevant if market power is always or never present over the period observed
Activation revenue expectations	• **Market participants may factor in their expected activation revenue within their reservation bids** – this could help explain a part of the unexplained variations in unit prices depending on market players' bidding strategies (but this may depend on their risk / bidding strategy)
Merit order effects	• In our model we controlled for technology shares in an attempt to capture possible merit order effects, particularly in pay-as bid markets. If a participant expects a particular technology to be price-setting, it should **attempt to bid according to that technology's own bid structure.** In that case, this pleads for the presence of net revenues beyond perfect arbitrage.
Imperfect price foresight	• As reservation auctions are carried out before the day ahead market, an **imperfect forecast of opportunity costs (whether looking at clean spark spread or price volatility) might lead to the unit prices not perfectly reflecting the actual opportunity cost of participation**
Assumptions taken for our analysis	• In our analysis, we have also taken some **assumptions to build our opportunity costs indicators**, for instance a particular efficiency factor for each technology to calculate the clean spark spread. While it is necessary to choose a value, the opportunity costs might be different in practice depending on which specific units provide balancing market services on each particular day; Other assumptions, such as gas sourcing strategies etc. could also limit the accuracy of our results
Model robustness	• **While informative from a correlation perspective, our results should be interpreted with care** – pooled econometric analysis without control groups limits 'causal' interpretations between our variables. In addition, we observe that a large share of variations in unit prices is not explained by our model, which could lead to other omitted variables impacting the coefficients observed.