Study on Cross-Border Balancing Market Design

Final Report

June 2023

CONFIDENTIAL

Contents

1.

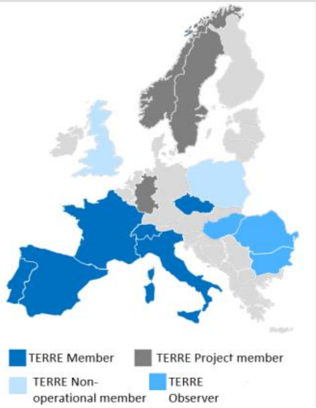
Context and objective of the project

The access to EU balancing platforms may provide significant benefits

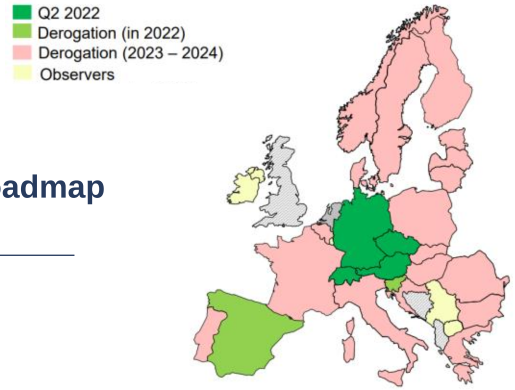
- The Electricity Balancing Guideline provides for the establishment of EU platforms where countries can share the resources used by their transmission system operators to balance generation and demand in real time. TERRE and MARI are two of the main platforms. They specifically enable to exchange manually activated balancing energy between TSOs.
- These platforms enable the mutualisation of resources, providing a range of benefits for all countries:
  - Additional resources in scarcity periods, supporting the integration of renewables;
  - Increased liquidity and competition in the national markets;
  - Reduced cost of balancing for final users.
- They notably take into account the availability of interconnectors and the different TSO needs.

TERRE Platform	MARI Platform
• Trans European Replacement Reserve Exchange • Exchange of balancing energy from replacement reserves (RR) • Implementation phase launched	• Manually Activated Reserves Initiative • Exchange of balancing energy from frequency restoration reserves with manual activation (mFRR) • Expected to be operational in Q2 2022

TERRE members (April 2021)



MARI Accession Roadmap (December 2021)



Note: For the moment, Switzerland is a member of TERRE and MARI but there are debates on its departure in the context of the negotiations between the EU and Switzerland.

Following the Brexit, the EU-UK Trade and Cooperation Agreement foresees a new procedure to enable exchange of balancing products between the UK and the EU

- Due to the Brexit, UK can no longer participate in the EU internal market for energy, and in particular in cross-border balancing platforms such as TERRE and MARI. However, the EU-UK Trade and Cooperation Agreement describes a number of processes to develop new working arrangements and technical procedures to coordinate with the European Union. One of the technical procedures required (under the Electricity Trading Arrangements) is a procedure for cross-border balancing. The aim of this procedure is to enable the exchange of balancing energy between ESO and other EU TSOs, via the interconnectors.
- Without a direct access to the EU platforms, the issue for cross-border balancing between the UK and the EU is the interaction between the different markets. The implementation of a **new UK market for balancing** that would be compatible with EU markets raises a number of issues:
    - **Competition between the different balancing markets and exchange platforms** (liquidity, distortions in the allocation of resources);
    - **Interactions with the intraday market**, incentivizing the actors to be balanced;
    - No harmonisation of mFRR and RR products between countries (e.g. **many countries connected to UK do not have RR**);
    - Timeline for auctions, activation, delivery;
    - IT development;
    - Consistency with wholesale electricity market reform, notably nodal pricing.
- Consequently, **NGESO mandated Compass Lexecon to carry out the modelling and a cost benefit analysis (CBA) of potential cross-border balancing** solutions under a range of plausible scenarios.

2.

Methodological approach and identification of CBB options

Overview of the methodology

	Criteria	Assessment
Economic efficiency		
	Economic welfare	The new mechanism should bring a positive net social welfare at the European level and at the UK level. The social welfare captures the better allocation of available resources.
	Impact on overall market signals	Balancing services should not reduce the incentive for stakeholders to be balanced in intraday. The new mechanism should not distort the efficient functioning of interconnectors.
	Impact on liquidity and competition	Liquidity and competition is the different markets are essential to ensure efficient price formation.
Security of supply		
	Security of supply	The SOs should have access to sufficient resources in order to stay balanced in very short timeframes.
Operational complexity		
	Operational impact	A new mechanism would have an impact on the way of functioning and likely the cost for developing a new platform.
	Robustness to changes	The potential changes to the UK and EU electricity markets shouldn't induce considerable adaptation costs.
Acceptability		
	Distribution of costs and benefits for stakeholders	The split between UK and EU BRPs/BSPs/consumers may require some compensation.
	Acceptability for neighbouring countries / TSOs	This acceptability could depend on benefits, operational difficulties and historic relationship with UK.
	Required changes in the regulatory framework	Specific references in EU guidelines and the TCA may require some adaptations.
Contribution to the energy transition (CO_2 emissions)		

1

Definition of the criteria for a cross-border balancing market

2

Identification and pre-screening of the options:
- Identification of the main options
- Pre-screening of the different options

3

Balancing market modelling set-up:
- Setting-up and calibration of the model
- Definition of the market fundamentals
- Parametrisation of the cross-border balancing options

4

Modelling and Cost-Benefit Analysis:
- Modelling and Cost-Benefit Analysis of base case
- Modelling of Cost-Benefit Analysis of sensitivities (6)

5

Multicriteria assessment and recommendations:
- Multi-criteria analysis
- Ranking of the options and recommendations

We have defined with NGESO a list of criteria to apply in a multi-criteria assessment methodology

Criteria	Assessment
Economic efficiency	
Economic welfare	The new mechanism should bring a positive net social welfare at the European level and at the UK level. The social welfare captures the better allocation of available resources.
Impact on overall market signals	Balancing services should not reduce the incentive for stakeholders to be balanced in intraday. The new mechanism should not distort the efficient functioning of interconnectors.
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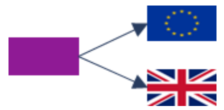
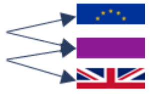
Robustness to changes	The potential changes to the UK and EU electricity markets shouldn’t induce considerable adaptation costs.
Acceptability	
Distribution of costs and benefits for stakeholders	The split between UK and EU BRPs/BSPs/consumers may require some compensation.
Acceptability for neighbouring countries / TSOs	This acceptability could depend on benefits, operational difficulties and historic relationship with UK.
Required changes in the regulatory framework	Specific references in EU guidelines and the TCA may require some adaptations.
Contribution to the energy transition (CO_2 emissions)	

We have identified several high level options for Cross-Border Balancing



1 A market before TERRE/MARI

- Activation in the UK CBB platform before having to submit bids for TERRE/MARI.
- Bids retained in the UK CB market cannot participate in the TERRE/MARI platforms.



2 Parallel markets – BSP choice

- BSPs choose to participate in the UK CBB or local platforms operating in parallel.
- Bids submitted on a market cannot participate in the other market.

3 Parallel markets – TSO allocation

- EU SOs and NGESO choose to offer/demand balancing between UK CBB or local platforms operating in parallel.
- TSOs have the possibility to reallocate the local bids depending on their anticipations.

4 Indirect participation to EU platform

- NGESO aggregates the UK bids/offers/needs and allocate them across the different frontiers.
- The resulting exchanges are allocated to the EU platforms for a unique clearing phase.

5 TSO directly nominate IC

- SOs directly exchange balancing products with each other. They may share bids of different characteristics and activate those which respond to their needs at minimum costs.
- If the SO-SO request is accepted, the SO can either wait for next auction to rebalance, either activate local resources (if legally/contractually possible).

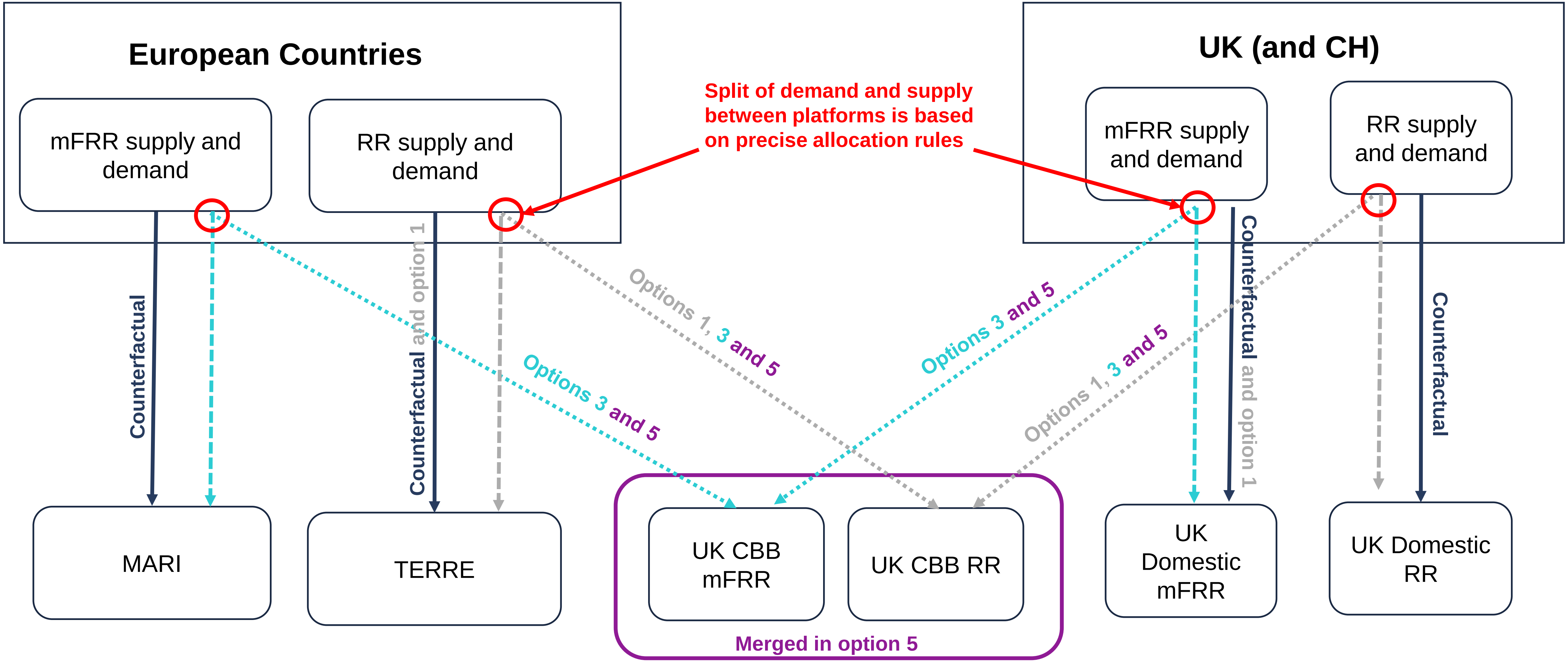
6 "Volume-coupling"-like

- The UK platform simulates the EU platforms' clearing at the UK+EU level and optimises exchanges between UK and EU.
- The resulting exchanges are allocated to the EU platforms for a second clearing phase.

Based on a pre-screening of options, we have narrowed down with NGESO options to be modelled considering trade-off between welfare and complexity

Option	Assessment	Keep for modelling?	
1 A market before TERRE/MARI	▪ Gains might be limited, but the implementation might be easier, especially in before TERRE. ▪ The difference of activation time could have an impact on other products, notably intra-day.	✓	
2 Parallel markets – BSP choice	▪ Induces a split of liquidity that may raise efficiency and potentially SoS concerns. ▪ May face legal issues.	✗	Due to difficulties to define BSPs' strategies, likely to lead to similar modelling results to option 3 although expected to be less efficient
3 Parallel markets – TSO allocation	▪ Induces a split of liquidity that may raise efficiency concerns. SOs' control may reduce them though. ▪ May face legal issues.	✓	
4 Indirect participation to EU platform	▪ Efficiency highly depends on ability of the ESO to allocate bids/offers in adequate bidding zones. ▪ Reciprocity and legality could be questioned.	✗	Very complicated to model, many uncertainties on allocation rules between bidding zones
5 TSO directly nominate IC	▪ Efficiency highly depends on ability of the SOs to exchange information at timeframes different from usual markets. Could potentially be limited. ▪ Operational complexity can be important.	✓	
6 "Volume-coupling"-like	▪ Likely most efficient, but complex, solution. ▪ Requires tight cooperation and data exchanges to work well. ▪ Day-ahead volume coupling faced implementation hurdles.	✗	Inefficiency compared to a perfect coupling situation is difficult to model

Illustration of the methodology used to model the options



Note: -In the counterfactual and the options, trades between countries of the platforms are limited by the interconnection capacity available after the Day-Ahead market.

- In option 1, as the UK CBB platform is before TERRE, it allows to replace the supply not selected in the UK CBB in TERRE and to have nuclear bids.

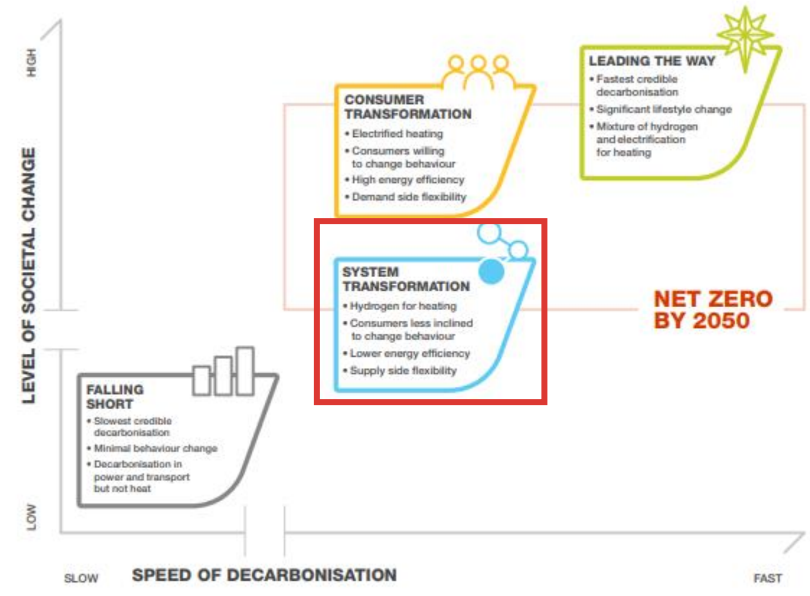
We use a Net Zero scenario across Europe as the market fundamentals in our study

We use the following scenario for market fundamentals:

- FES 22 scenario ‘System Transformation’ – “ST” for UK demand, capacity and interconnections
- TYNDP 22 scenario ‘Global Ambition’ – “GA” for the rest of Europe (demand and capacity)
- TYNDP 22 scenario “CBA Reference Grid” for the rest of Europe (interconnections)
- WEO 22 scenario ‘Announced Pledges’ for commodity prices.

This ensure a consistent scenario across Europe reflecting countries commitment to reach net zero emissions in 2050.

FES 22 “System Transformation”



TYNDP 22 “Global Ambition”

		Distributed Energy Higher European autonomy with renewable and decentralised focus	Global Ambition Global economy with centralised low carbon and RES options
Green Transition		At least a 55 % reduction in 2030, climate neutral in 2050	
Driving force of the energy transition		Transition initiated at a local/national level (prosumers)	Transition initiated at a European/international level
		Aims for EU energy autonomy through maximisation of RES and smart sector integration (P2G/L)	High EU RES development supplemented with low carbon energy and imports
Energy intensity		Reduced energy demand through circularity and better energy consumption behaviour	Energy demand also declines, but priority is given to decarbonisation of energy supply
		Digitalisation driven by prosumer and variable RES management	Digitalisation and automation reinforce competitiveness of EU business
Technologies		Focus of decentralised technologies (PV, batteries, etc.) and smart charging	Focus on large scale technologies (offshore wind, large storage)
		Focus on electric heat pumps and district heating	Focus on hybrid heating technology
		Higher share of EV, with e-liquids and biofuels supplementing for heavy transport	Wide range of technologies across mobility sectors (electricity, hydrogen and biofuels)
		Minimal CCS and nuclear	Integration of nuclear and CCS

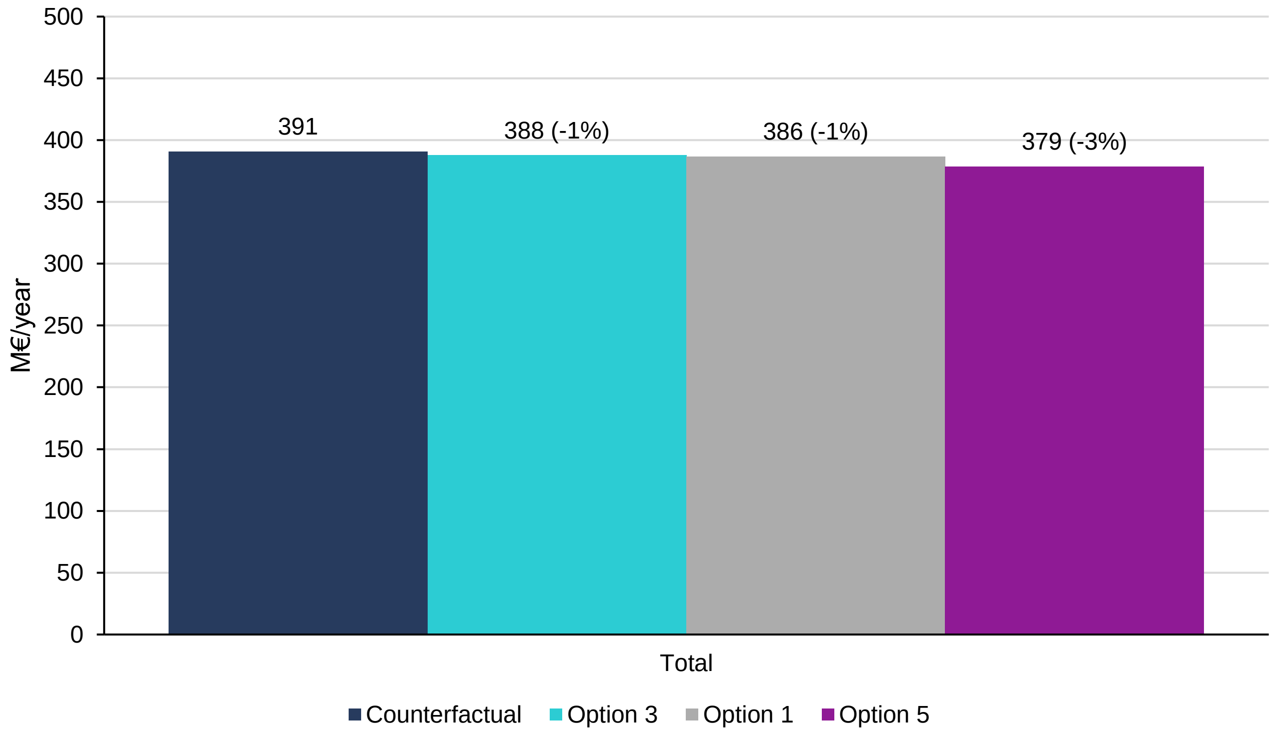
Figure 2: Storylines for the two COP21 scenarios

3.

Base Case – Modelling results

Cross-border balancing options not based on the participation of GB in EU platforms have a limited impact on social welfare (limited cost reduction)

Activation cost – Different Options – Average 2030-2040 - Base Case

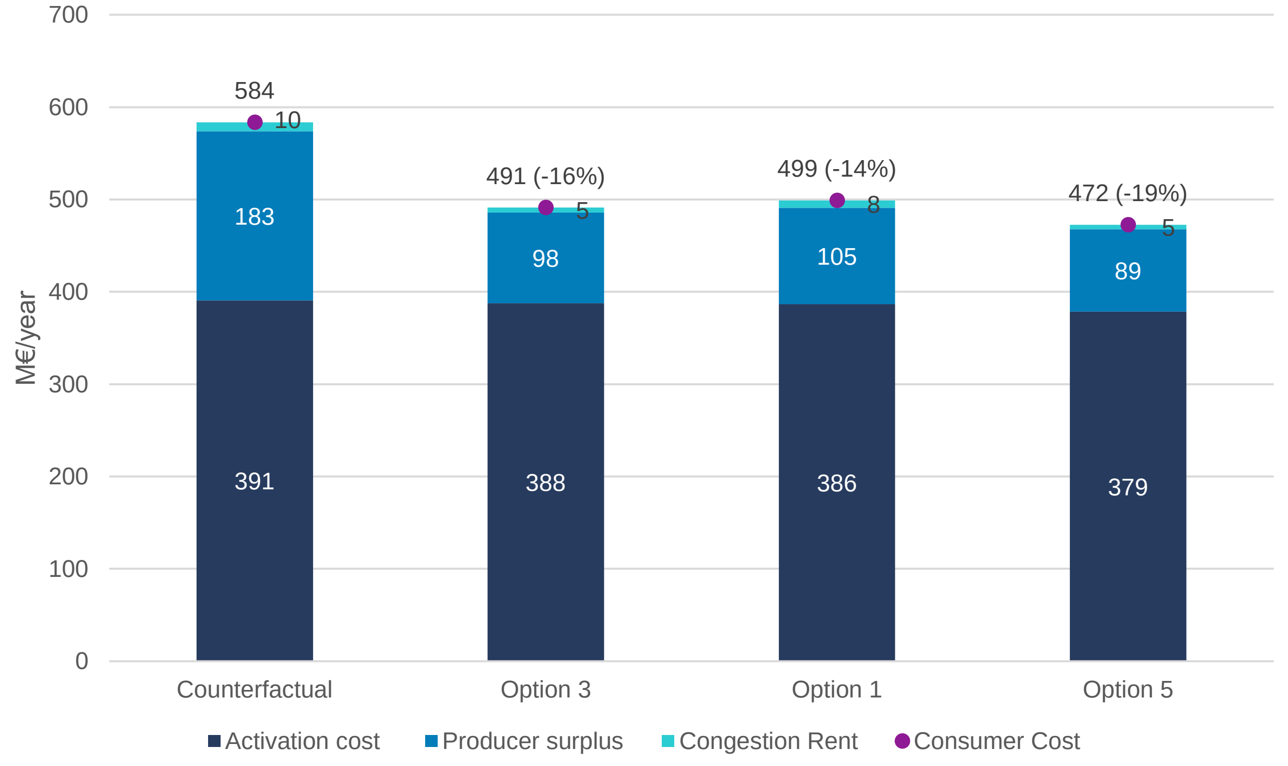


Activation cost is the sum of the activation costs of power plants over all modelled countries. The difference of activation costs between counterfactual and options represents the gain made by the platforms.

- In the base case, **activation costs are around 400M€.** Cross-border balancing **options not based on the participation of GB in EU platforms lead to a reduction** of balancing activation costs of 1% to 3% between the counterfactual and the options over the period.
- Option 5 seems to be the most economically efficient. However, **the benefits of this approach are likely overestimated** – all other things being equal – **due to the modelling approach as it combines and cross-optimises two products that have different characteristics** in particular as regards activation times (from 12.5min in mFRR to 30min in RR). In practice, TSOs would unlikely be technically able to fully merge the merit orders.
- **Option 1 reduces activation costs to a limited extent (1%)** but raises major implementation issues as it forces TSOs to anticipate gate closure, having significant impacts on markets and operational procedures. **The ability to reach these benefits can also be questioned**. Anticipating intraday gate closure could affect their efficiency and these negative impacts may outweigh the benefits of CBB. Moreover, TSOs will have to anticipate their balancing needs' estimations, with higher risks of getting it wrong. This could dampen the overall efficiency of balancing, which is not captured in the model.
- The modelling of these options also relies on several important assumptions about the sharing of supply and demand:
  - (i) on the ability to share supply on EU side as EU TSOs participating in TERRE / MARI have a legal obligation to place all their supply on these platforms, so it would require a regulatory change for this supply to be placed on the UK CBB platform;
  - (ii) on the sharing strategy implemented in practice by TSOs: the learning effect is not taken into account, as sharing may lead to inefficiencies, TSOs and producers would adjust their strategy (e.g. by putting less demand, or at very specific times)

Cross-border balancing options reduce consumer costs, mainly due to the breakdown of demand obtained through the platforms

Consumer cost – Different Options – Average 2030-2040 – Base Case



Consumer cost represents the cost paid by the final consumer (represented by the TSO in BMs), i.e. the load multiplied by the price paid for each of the countries modelled (deducted from revenues in downward mFRR and RR when the plants bought back their electricity)

- **Cross-border balancing options lead to a significant reduction** of consumer costs, because of **the rules for allocating demand between UK CBB and TERRE / MARI platforms and to price formation.**
- Indeed, the **reduction of demand in EU platforms** (and UK domestic markets) together with the sharing of the less expensive offers on these platforms lead to a price reduction in these platforms, hence applied to large volume. This **reduction in prices in these platforms largely exceeds the similar or higher prices observed on the UK CBB platform**.
- In addition, **TSOs may also adapt the post-processing of the selection of the bids and their pricing**, that may impact the split of costs and benefits between producers and consumers.
- **Option 5 seems to offer the greatest reduction in consumer costs**, but this is subject to the same limitations as regards the technical possibility of merging merit orders of two different products.

Illustration of the demand breakdown leading to a significant decrease in consumer costs compared to the counterfactual

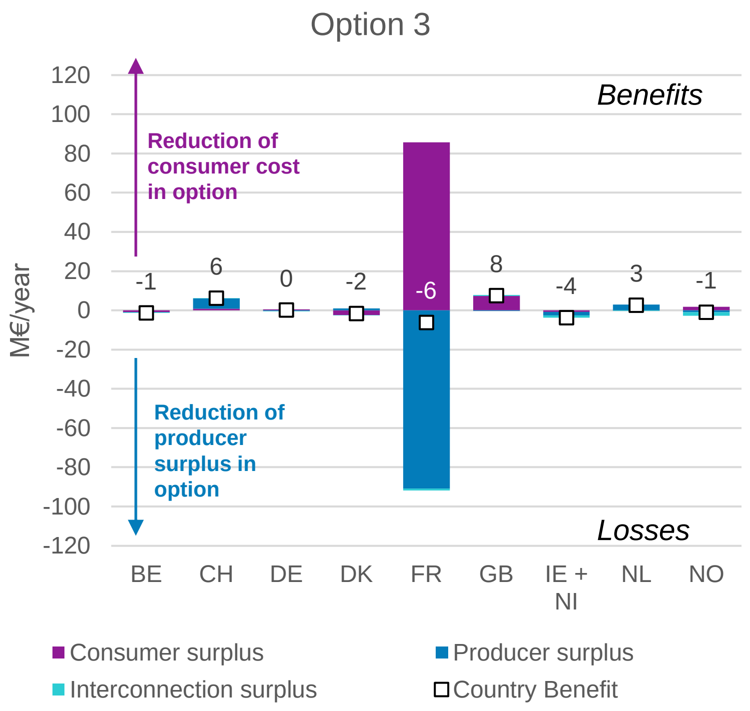
Load / Price / Consumer Cost – France and GB – Counterfactual vs Option 3 – Upward RR – 2030

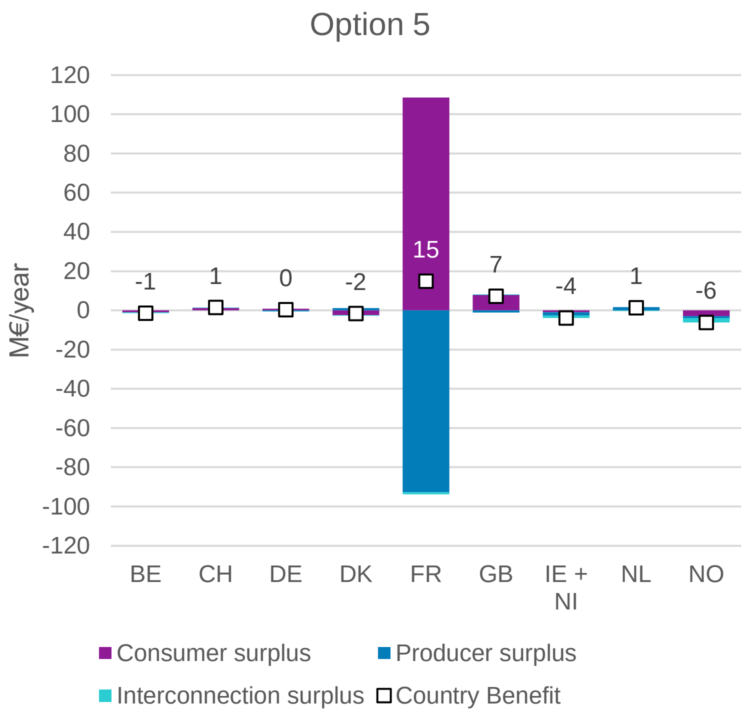
	Counterfactual		Option 3			
	FR – TERRE	UK – Domestic Market	FR - TERRE	FR – UK CBB	UK – Domestic Market	UK – UK CBB
Load (GWh)	1739	6.5	1479	260	5	1.5
Average annual price (€/MWh)	188	153	132	220	146	131
Load-weighted average price (€/MWh)	188	153	145		143	
Consumer Cost (M€)	327	1.0	252		0.9	

- To illustrate the impact of the demand breakdown on the consumer cost, we use the example of the upward RR in option 3 in 2030 for France and Great Britain.
- In France, we see that the **reduction of demand in TERRE** together with the sharing of the less expensive offers lead to a price reduction in TERRE (from 188€/MWh to 132€/MWh), hence applied to large volume (1479GWh). This **reduction in prices largely exceeds the slightly higher prices for France in the UK CBB platform (220€/MWh)**. In the end, the reduction in consumer cost for France is very significant (from 327M€ to 252M€).
- For Great Britain, we see that the **reduction in demand on its domestic market together with the sharing of the** less expensive offers **leads to a reduction in prices on its domestic market (from 153€/MWh to 146€/MWh).** This price reduction also appears on the UK CBB platform (132€/MWh).

Options 3 and 5 lead to lower consumer costs in France and GB but lower producer surplus in France

Country costs/benefits – Options vs counterfactual – Average 2030-2040 – Base Case





- *Consumer surplus represents the difference of consumer costs between counterfactual and option.*
- *Producer surplus represents the difference of producer surplus between counterfactual and option.*
- *Interconnection surplus represents the difference of congestion rents between counterfactual and option.*
- *Country benefit represents the sum of the three previous indicators.*

- In both options, **the implementation of the UK CBB platform reduces the consumer cost in France (positive consumer surplus)** with cheaper supply made available in the UK and CH as well as through the demand sharing effect as explained previously. But the reduction in prices also leads to a reduction **in French producer surplus**.
- In option 5, the decrease in consumer cost in France exceeds the decrease in producer surplus in option 5, thanks in particular to the mFRR offers which make it possible to cover part of the demand in RR, **resulting in a positive country benefit (+15M€).**
- In option 3, the decrease in consumer cost in France does not fully compensate the decrease in producer surplus, **resulting in a negative country benefit (-6M€).**
- The **country benefit for Great Britain remains quite stable in both options, positive by 7M€ to 8M€,** mainly due to the consumer surplus related to lower activation costs, mainly in mFRR.

Note: As the country results for Option 1 do not involve all countries in the scope of the study, we focus here only on Options 3 and 5. Details of Option 1 by country are presented in the long report.

4.

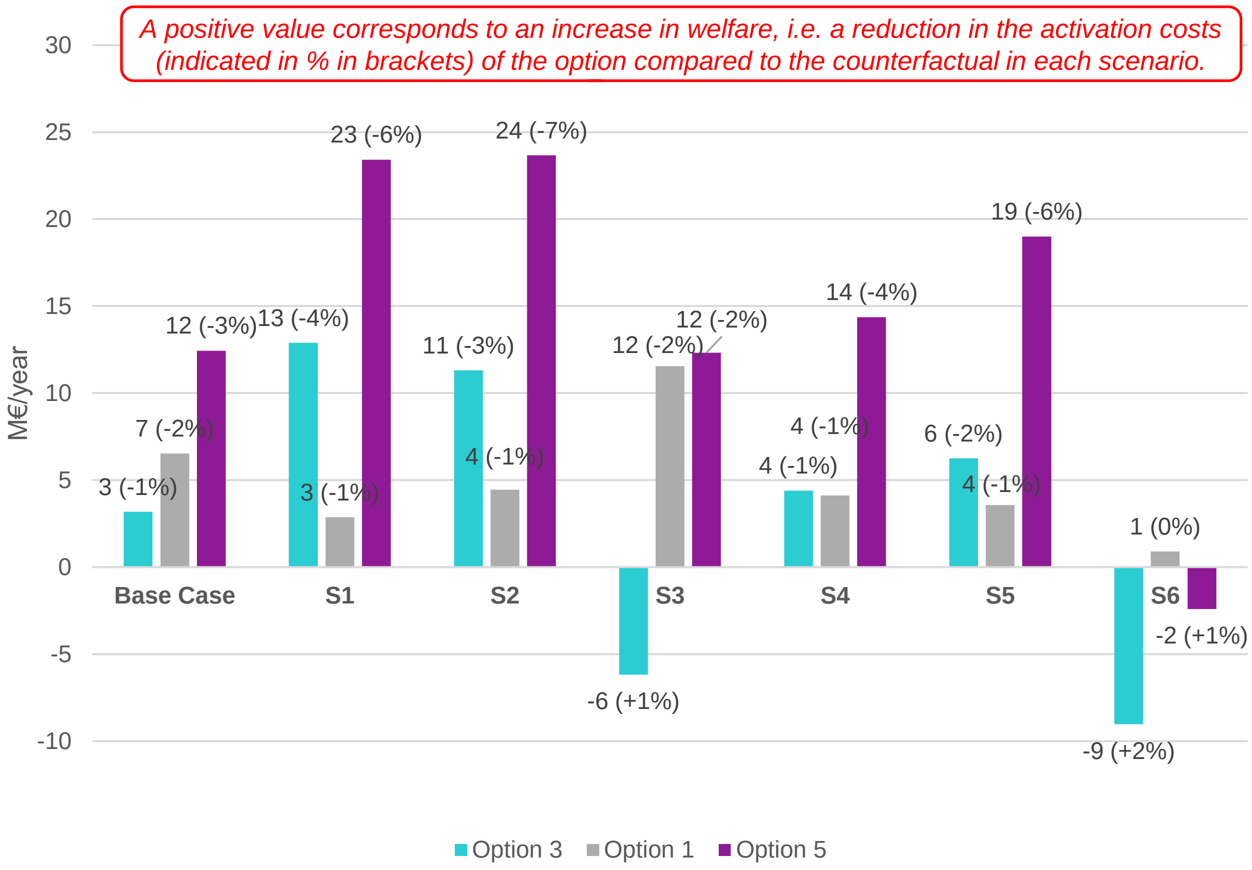
Sensitivity Modelling Results

List of sensitivities to assess the uncertainties in these markets

	Sensitivity	Description
1	Swapping Hydrogen out for Electrification of heating (GB)	We consider a higher electrification of heating than in the base case (from 16 to 28 TWh) but a lower production of hydrogen by electrolysis (from 12 to 4 TWh). We use the values from the Consumer Transformation scenario (FES 22) instead of the System Transformation scenario (FES 22) in the base case.
2	UK interconnection capacity of 25GW from 2030	We use an UK interconnection capacity of 25GW in 2030 instead of 13GW in the base case.
3	High gas prices in the long term	Due to a gas shortage in Europe because of the war in Ukraine, gas prices will remain high in the long term (i.e. 75€/MWh in 2030 instead of 25€/MWh in the base case), with gas imports remaining low and relying mainly on LNG imports.
4	More renewables in European countries	We consider more renewables in European countries: more offshore wind in Norway, more offshore wind in Sweden, more onshore wind and solar in Germany.
5	Increased involvement of new technologies	We consider the involvement of new technologies to be twice as high in terms of proposed volumes as in the base case.
6	Share of balancing bids between domestic and cross-border platforms	We consider a different share of balancing bids between domestic and cross-border platforms, placing 10% of bids on the UK CBB platform (rather than 30% in the base case) to represent a very constrained transmission network.

Compared to the counterfactual, options generally reduce the activation costs, but in rather small proportions (less than 7%) and sometimes even have a higher activation cost than the counterfactual

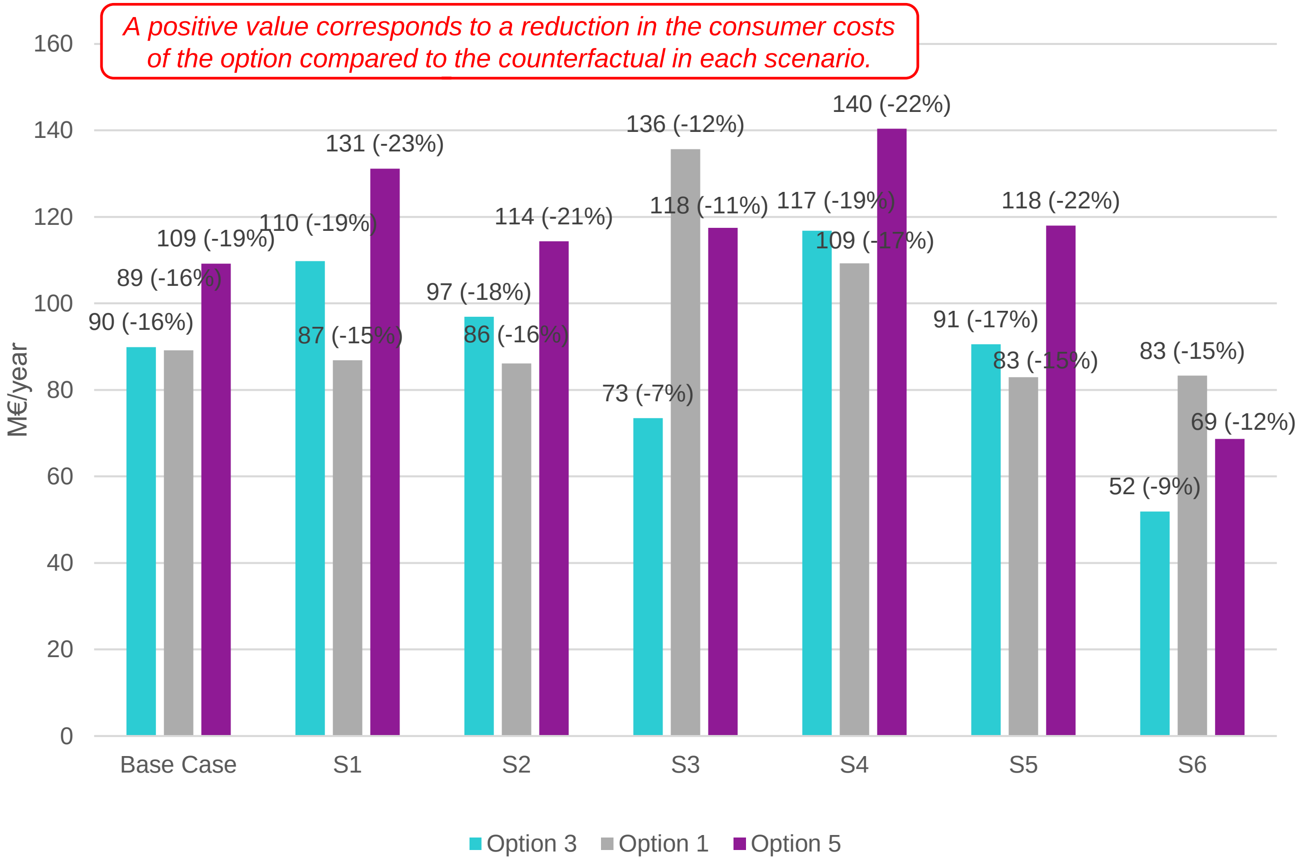
Additional welfare – Delta between Options and Counterfactual – 2030 – Base Case and Sensitivities 1 to 6 (S1 to S6)



- **Benefits of CBB tend to increase with higher interconnection, higher heating electrification or higher participation of new technologies.**
- **Option 5 is the most economically efficient of the options.** However, **the benefits of this approach are likely overestimated – all other things being equal – due to the modelling approach as it combines and cross-optimises two products that have different characteristics** (as explained before). Therefore, in practice, TSOs would unlikely be technically able to fully merge the merit orders.
- **Option 1 also reduces activation costs compared to the counterfactual, although to a lesser extent than Option 5.** This option raises major implementation questions as it forces TSOs to anticipate the gate closure, having significant impacts on markets and operational procedures.
- **Option 3 also reduces activation costs but to a lesser extent and not in all scenarios.** In sensitivity 6, **a very constrained transmission** means a lower allocation of bids to the UK CBB platform resulting in **higher activation costs in options 3 and 5** than in the counterfactual.

Cross-border balancing options reduce the consumer costs compared to the counterfactual in all sensitivities, mainly due to the breakdown of demand obtained through the platforms

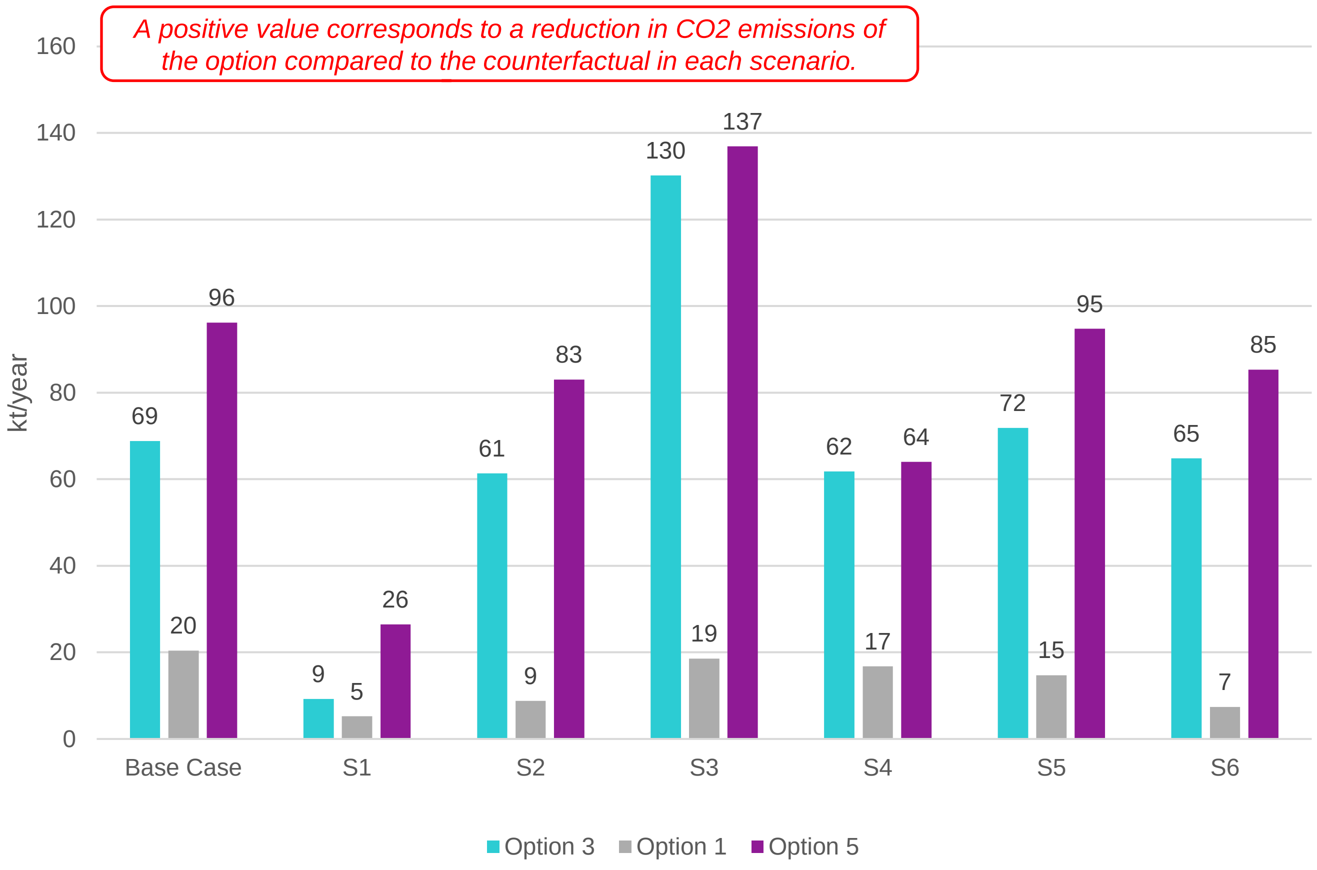
Consumer cost reduction – Delta between Options and Counterfactual – 2030 – Base Case and Sensitivities 1 to 6 (S1 to S6)



- **As in the base case, cross-border balancing options lead to a significant reduction** of consumer costs in all sensitivities, because of **the rules for allocating demand between UK CBB and TERRE / MARI platforms and to price formation.**
- Indeed, the **reduction of demand in EU platforms** (and UK domestic markets) together with the sharing of the less expensive offers lead to a price reduction in the EU platforms, hence applied to large volume. This **reduction in prices in these platforms largely exceeds the similar or slightly higher prices in the UK CBB platform**.
- In addition, **TSOs may also adapt the post-processing of the selection of the bids and their pricing**, that may impact the split of costs and benefits between producers and consumers.
- **In most scenarios, option 5 seems to offer the greatest reduction in consumer costs**, but subject to the same limitations in the technical possibility of merging merit orders of two different products, as explained previously.

Cross-border balancing options allow for a reduction in CO2 emissions, albeit quite moderate when compared to the emissions of the overall power system

Reduction in CO2 emissions – Delta between Options and Counterfactual – 2030 – Base Case and Sensitivities 1 to 6 (S1 to S6)



- **Cross-border balancing options lead to a significant reduction** of consumer costs in the base case and in all sensitivities.
- **Options 3 and 5 allow a significant reduction in CO2 emissions compared to the counterfactual** by allowing more decarbonised supply to be shared in upward mFRR and upward RR and more thermal supply to be shared in downward mFRR and downward RR.
- However, **CO2 emissions levels avoided by these options remain quite low when compared to the overall emissions of the power system, of the order of 200Mt in 2030 in our power dispatch model.**

5.

Multicriteria assessment and recommendations

Modelling has resulted in lower economic welfare for parallel markets than expected, other options seem more favourable

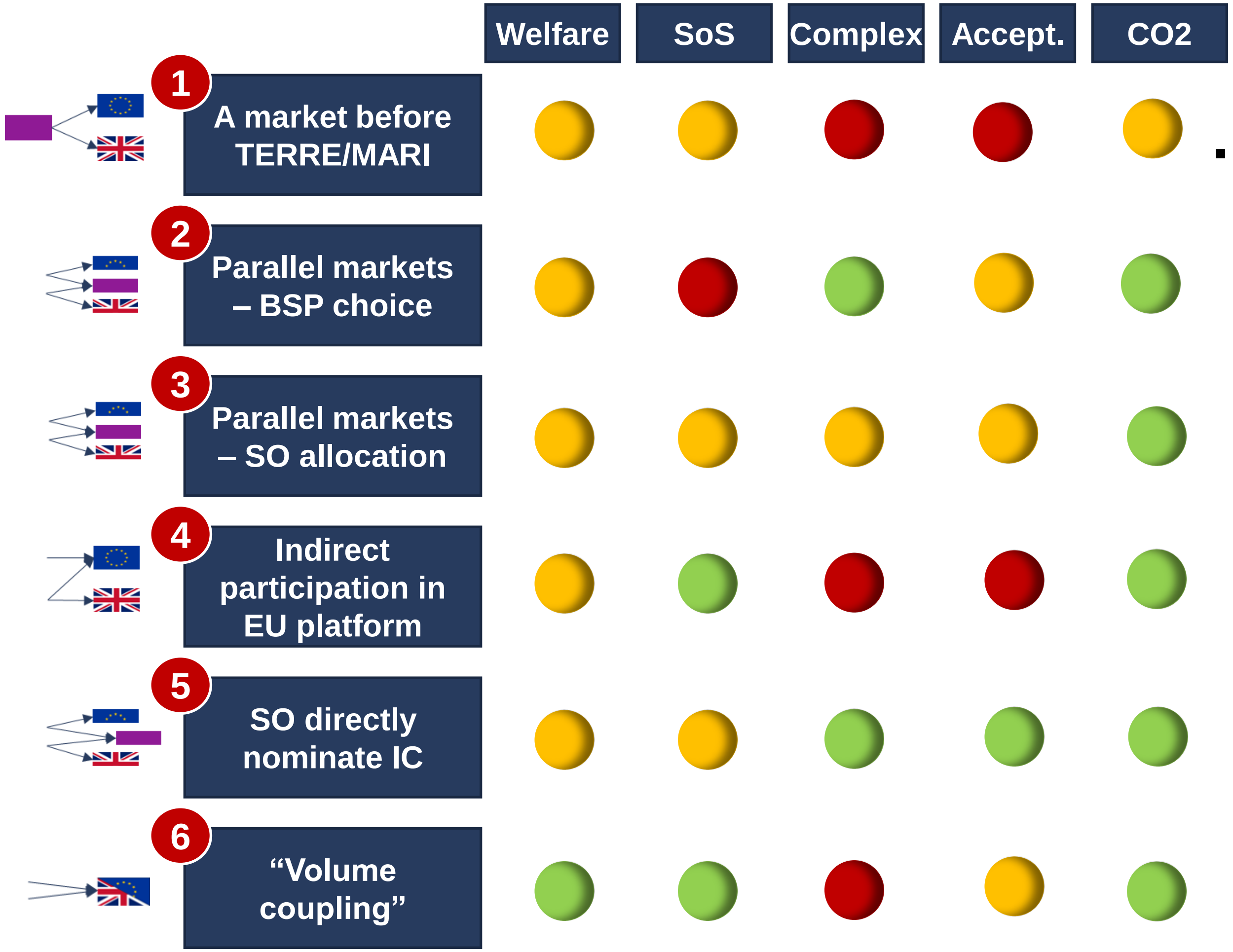
	Economic welfare	Market signal	Liquidity & Competition	Economic Efficiency
1 A market before TERRE/MARI	**About 6M€/year** Results are consistent through sensitivities but impact on ID	Interactions with intraday market and cross-zonal gate closure	Particip. of longer activation times resources, but to the detriment of ID	
2 Parallel markets – BSP choice	**Likely below option 3** Benefits below option 3 as SO have more information	Limited impact on existing markets	Possibility for BSP to avoid the platform because of IC uncertainty.	
3 Parallel markets – SO allocation	**About 3M€/year** Net benefits are negative in certain sensitivities	Limited impact on existing markets	Possibility for SO to avoid the platform because of SoS issues.	
4 Indirect participation in EU platform	**Likely close to Option 3** depends on implementation / NGESO decisions	Limited impact on existing markets	Possibility for NGESO to avoid the platform because of SoS issues	
5 SO directly nominate IC	**Below 12M€/year** Higher range of benefits, but likely lower in practice.	Merging mFRR and RR may modify market signal	Potentially combines mFRR and RR, broadening the pool of resources.	
6 "Volume coupling"	**Likely close to optimum** but strongly depending on implementation	Limited impact on existing markets	Economic efficiency could be close to optimum	

Options 3 and 5 appear to be the most adequate in terms of SoS, complexity and acceptability

	Security of supply	Operational complexity	Acceptability	Energy Transition
1 A market before TERRE/MARI	Risk of higher imbalances due to earlier ID GCT, but higher balancing resources	Delay ID and IC GCT, leading to numerous operational changes	Delay ID and IC GCT, leading to numerous changes in UK and in EU	**About 15 kt/year** Net benefits are negative in certain sensitivities
2 Parallel markets – BSP choice	Could cause security of supply issues, as it could split liquidity/ reduce resources	Limited impact on existing markets. SO have a say on BSP offers in a constr. timeline.	Local framework may require BSPs to provide all capacity in EU or local platforms	**Likely below option 3** Benefits below option 3 as SO have more information
3 Parallel markets – SO allocation	Could cause security of supply issues, but more limited than option 2 as SO have control	Limited impact on existing markets Constrained timelines for SO	Local framework may require SOs to provide all capacity in EU or local platforms	**About 75 kt/year** Results are consistent through sensitivities
4 Indirect participation in EU platform	Limited impact on existing markets, should not prevent SOs to find resources	The dispatching of the UK position across the connected countries may be complicated	Compatibility of UK “fictive” BSP to EU regulation in question – Reciprocity?	**Likely close to Option 3** depends on implementat. / NGESO decisions
5 SO directly nominate IC	Limited impact on existing markets, should not prevent SOs to find resources	Limited operational impact on EU platforms, but requires a new process between SOs	Cooperation could be done country-by-country	**Below 85 kt/year** We modelled the higher range of benefits.
6 “Volume coupling”	Likely to increase accessible resources, conditionally to efficient implementation.	Adding additional processes in tight timelines may require trade-offs	Data restrictions similar to LVC could apply	**Likely close to optimum** but strongly depending on implementation

Note: ID = Intraday, IC InterConnector, GCT = Gate Closure Time, SO = System Operator, LVC = Loose Volume Coupling

The different options imply a trade-off between welfare and complexity



Option 6 - “Volume Coupling” would likely provide the highest welfare – close to a full participation of UK to EU platforms – and increase security of supply, although its **operational complexity could be a barrier to its implementation**.

- On the other hand, other options would likely provide modest benefits, which will also greatly depend on how bids/offers will be split between domestic markets and the UK-EU CBB platform.
  - Option 1 would involve a limited number of countries, but may provide benefits. **The main obstacle of this option is the operational implications**, as the ID GCT would need to be anticipated. This could be complex, detrimental to the overall efficiency of the market and unacceptable to many stakeholders, including TSOs.
  - Options 2 and 3 **would require lower complexity, but our modelling has shown limited economic benefits** – about 3M€/year and could even be negative. These benefits would be highly subject to the learning process of TSOs (and BSPs in option 2), which may desert the CBB or on the contrary optimise and coordinate their participation to improve results. The legal possibility of sharing bids for EU parties would have to be confirmed as it seems contradictory to EU regulation. Finally, option 2 leads to a loss of visibility and control on available resources, which could affect security of supply.
  - **The benefits of option 4 are difficult to capture** as it depends on the ability to split net demand and offer amongst the different interconnectors. Moreover, beyond its complexity, **this option is likely to face legal barriers to the participation of a UK representative party in EU platforms and lack of acceptability** as it could be perceived as asymmetric and non reciprocal.
  - **Option 5 appears as a pragmatic approach** although its actual benefits depend on the actual use of the CBB platform by the TSOs. The modelling results are **likely overestimating the benefits** for a given participation strategy as it does not fully reflect the technical characteristics and needs. This may **lead to a situation of low benefits compared to high implementation costs**.

Key takeaways

1. All the options analysed present some drawbacks and/or **operational difficulties** and the **modelling of these options is complex** as it **strongly depends on how these options will be operationally used by the SOs** and to what extent they will share their supply and demands.

2. **The most promising options seem to be option 5** where TSOs voluntarily share balancing bids and offers and can request activations on an ad hoc basis and **possibly option 3** with parallel markets and where TSOs allocate supply and demand between the domestic/EU platforms and the UK CBB platforms.

3. Option 1 (a market before TERRE/MARI), option 4 (indirect participation in EU platform) and option 6 (Volume coupling) **present very significant complexities and depend heavily on the willingness of TSOs to engage in this integration work.**

1.

Methodology, definition of the criteria, identification of the options and balancing market modelling set-up

Overview of the methodology

Criteria		Assessment
Economic efficiency		
	Economic welfare	The new mechanism should bring a positive net social welfare at the European level and at the UK level. The social welfare captures the better allocation of available resources.
	Impact on overall market signals	Balancing services should not reduce the incentive for stakeholders to be balanced in intraday. The new mechanism should not distort the efficient functioning of interconnectors.
	Impact on liquidity and competition	Liquidity and competition is the different markets are essential to ensure efficient price formation.
Security of supply		
	Security of supply	The SOs should have access to sufficient resources in order to stay balanced in very short timeframes.
Operational complexity		
	Operational impact	A new mechanism would have an impact on the way of functioning and likely the cost for developing a new platform.
	Robustness to changes	The potential changes to the UK and EU electricity markets shouldn't induce considerable adaptation costs.
Acceptability		
	Distribution of costs and benefits for stakeholders	The split between UK and EU BRPs/BSPs/consumers may require some compensation.
	Acceptability for neighbouring countries / TSOs	This acceptability could depend on benefits, operational difficulties and historic relationship with UK.
	Required changes in the regulatory framework	Specific references in EU guidelines and the TCA may require some adaptations.
Contribution to the energy transition (CO_2 emissions)		

1

Definition of the criteria for a cross-border balancing market

2

Identification and pre-screening of the options:
- Identification of the main options
- Pre-screening of the different options

3

Balancing market modelling set-up:
- Setting-up and calibration of the model
- Definition of the market fundamentals
- Parametrisation of the cross-border balancing options

4

Modelling and Cost-Benefit Analysis:
- Modelling and Cost-Benefit Analysis of base case
- Modelling of Cost-Benefit Analysis of sensitivities (6)

5

Multicriteria assessment and recommendations:
- Multi-criteria analysis
- Ranking of the options and recommendations

We have defined with NGESO a list of criteria to apply in a multi-criteria assessment methodology

Criteria	Assessment
Economic efficiency	
Economic welfare	The new mechanism should bring a positive net social welfare at the European level and at the UK level. The social welfare captures the better allocation of available resources.
Impact on overall market signals	Balancing services should not reduce the incentive for stakeholders to be balanced in intraday. The new mechanism should not distort the efficient functioning of interconnectors.
Impact on liquidity and competition	Liquidity and competition is the different markets are essential to ensure efficient price formation.
Security of supply	
Security of supply	The SOs should have access to sufficient resources in order to stay balanced in very short timeframes.
Operational complexity	
Operational impact	A new mechanism would have an impact on the way of functioning and likely the cost for developing a new platform.
Robustness to changes	The potential changes to the UK and EU electricity markets shouldn't induce considerable adaptation costs.
Acceptability	
Distribution of costs and benefits for stakeholders	The split between UK and EU BRPs/BSPs/consumers may require some compensation.
Acceptability for neighbouring countries / TSOs	This acceptability could depend on benefits, operational difficulties and historic relationship with UK.
Required changes in the regulatory framework	Specific references in EU guidelines and the TCA may require some adaptations.
Contribution to the energy transition (CO_2 emissions)	

The economic efficiency criteria and the contribution to the energy transition (CO2 emissions) are assessed through modelling

❑ **Several global economic efficiency indicators are studied:**

- Activation cost: represents the sum of the activation costs of power plants over all modelled countries. It incorporates upward mFRR and RR and downward mFRR and RR. In downward mFRR and RR, power plants buy back their electricity from the TSO most of the time and these TSO revenues in Down are therefore deducted from the upward mFRR and RR activation costs. **The difference of activation costs between options represents the most relevant economic efficiency criteria.**
- Producer surplus: represents the difference of the price received by plants and their activation costs (or the maximum price at which power plants would have been willing to buy their electricity in Down) over all modelled countries.
- Congestion rent: represents the rent from price differences between countries arising from limited interconnection capacity
- Consumer cost: represents the cost paid by the final consumer (represented by the TSO), i.e. the load multiplied by the price paid for each of the countries modelled (deducted from revenues in Down when the plants bought back their electricity). It is the sum of activation cost, producer surplus and congestion rent.

❑ **Several indicators of economic efficiency by country are also studied:**

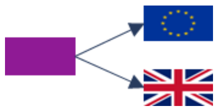
- Consumer surplus: represents the difference of the consumer costs between the counterfactual and the option studied
- Producer surplus: represents the difference of the producer surplus between the counterfactual and the option studied
- Interconnection surplus: represents the difference of the congestion rent between the counterfactual and the option studied
- Country benefit: represents the sum of consumer surplus, producer surplus and interconnection surplus.

❑ **For the energy transition criteria, we look at the avoided CO2 emissions:**

- Avoided CO2 emissions: represents the difference of the CO2 emissions between the counterfactual and the option studied

Note: The criteria of security of supply, operational complexity and acceptability are assessed qualitatively.

We have identified several high level options for Cross-Border Balancing



1 A market before TERRE/MARI

- Activation in the UK CBB platform before having to submit bids for TERRE/MARI.
- Bids retained in the UK CB market cannot participate in the TERRE/MARI platforms.

2 Parallel markets – BSP choice

- BSPs choose to participate in the UK CBB or local platforms operating in parallel.
- Bids submitted on a market cannot participate in the other market.

3 Parallel markets – TSO allocation

- EU SOs and NGESO choose to offer/demand balancing between UK CBB or local platforms operating in parallel.
- TSOs have the possibility to reallocate the local bids depending on their anticipations.

4 Indirect participation in EU platform

- NGESO aggregates the UK bids/offers/needs and allocate them across the different frontiers.
- The resulting exchanges are allocated to the EU platforms for a unique clearing phase.

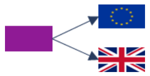
5 TSO directly nominate IC

- SOs directly exchange balancing products with each other. They may share bids of different characteristics and activate those which respond to their needs at minimum costs.
- If the SO-SO request is accepted, the SO can either wait for next auction to rebalance, either activate local resources (if legally/contractually possible).

6 "Volume-coupling"

- The UK platform simulates the EU platforms' clearing at the UK+EU level and optimises exchanges between UK and EU.
- The resulting exchanges are allocated to the EU platforms for a second clearing phase.

Based on a pre-screening of options, we have narrowed down with NGESO options to be modelled considering trade-off between welfare and complexity

Option	Assessment	Keep for modelling?	
 1 A market before TERRE/MARI	▪ Gains might be limited, but the implementation might be easier, especially in before TERRE. ▪ The difference of activation time could have an impact on other products, notably intra-day.	✓	
 2 Parallel markets – BSP choice	▪ Induces a split of liquidity that may raise efficiency and potentially SoS concerns. ▪ May face legal issues.	✗	Due to difficulties to define BSPs' strategies, likely to lead to similar modelling results to option 3 although expected to be less efficient
 3 Parallel markets – TSO allocation	▪ Induces a split of liquidity that may raise efficiency concerns. SOs' control may reduce them though. ▪ May face legal issues.	✓	
 4 Indirect participation in EU platform	▪ Efficiency highly depends on ability of the ESO to allocate bids/offers in adequate bidding zones. ▪ Reciprocity and legality could be questioned.	✗	Very complicated to model, many uncertainties on allocation rules between bidding zones
 5 TSO directly nominate IC	▪ Efficiency highly depends on ability of the SOs to exchange information at timeframes different from usual markets. Could potentially be limited. ▪ Operational complexity can be important.	✓	
 6 "Volume-coupling"-like	▪ Likely most efficient, but complex, solution. ▪ Requires tight cooperation and data exchanges to work well. ▪ Day-ahead volume coupling faced implementation hurdles.	✗	Inefficiency compared to a perfect coupling situation is difficult to model

The results of this study are based on our balancing market model, which consists of three steps: power market dispatch model, capacity reservation market and energy activation market

Inputs

- Demand
- Fuel
- Hourly Renewable profile
- Plant build / retirement
- Operating costs / constraints
- Interconnector capacity incl. ramping constraints/MPIs

Regulation

- Prequalification requirements
- Frequency of auctions, length of blocks
- Common markets
- **Technologies allowed to participate**
- **Clearing methodology**

- The auction for capacity reservation and energy activation are based on opportunity costs.

Balancing market model

Capacity reservation market

- Capacity demand
- Market participants
- Capacity bids (volume & price)

→ We model a simplified capacity reservation that focuses on volumes retained for possible activation.

→ Restricted model (IE, UK, FR, CH, BE, NL, DE, DK, NO)

Energy activation market

- Required energy activation
- Energy bids (volume & price)
- Free bids

→ The different technologies are assessed on the basis of the merit order. Marginal cost takes into account pricing from market player in the past.

→ Restricted model (IE, UK, FR, CH, BE, NL, DE, DK, NO)

Power market dispatch model

- Hourly generation dispatch
- Optimization of operational constraints
- Co-optimization of hydro and thermal generation

→ The power market takes into account volumes dedicated to balancing and additional revenues for the utilities' strategic decisions.

→ EU model

Outputs

- Selected participants in the capacity auction, hourly
- Selected participants for energy activation, hourly
- Clearing price in the capacity auction and energy activation auction
- Captured remuneration per technology

The three steps of the model are done consecutively, with the outputs of one step being used as inputs to the following steps

1

Mod
el

European power day-ahead (DA) market model

Outp
uts

Hourly power prices
Production plan for all plants

2

Inputs

Capacity demand

Based on DA market outputs:
Market participants, Volume and price of capacity bids

Model

Capacity auction:
Our model runs the capacity auction to select the cheapest units to be booked in advance for energy activation for each ancillary service

Outputs

Selected units per hour
(Hourly capacity reservation price)

3

Inputs

Required Energy Activation
Based on DA market outputs:
Market participants (free bids), volume and price of energy bids (by free bidders)
Based on Capacity Reservation market outputs
Volume and price of energy bids (by reserved capacity)

Model

Energy Activation:
Our models runs the energy activation block to activate the energy of the booked units from the previous step. This energy allows to resorb system imbalances. Energy activation can be shared between several platforms (TERRE, MARI, UK CBB platform, etc.)

1) Day-Ahead Market model:

Definition of the day-ahead market fundamentals' scenario next slide.

2) Capacity Reservation:

Demand based on historical data or TSO projections (if available)

Split of the supply between mFRR and RR according to the calibration performed

3) Energy Activation:

Supply based on calibration performed and demand based on historical data

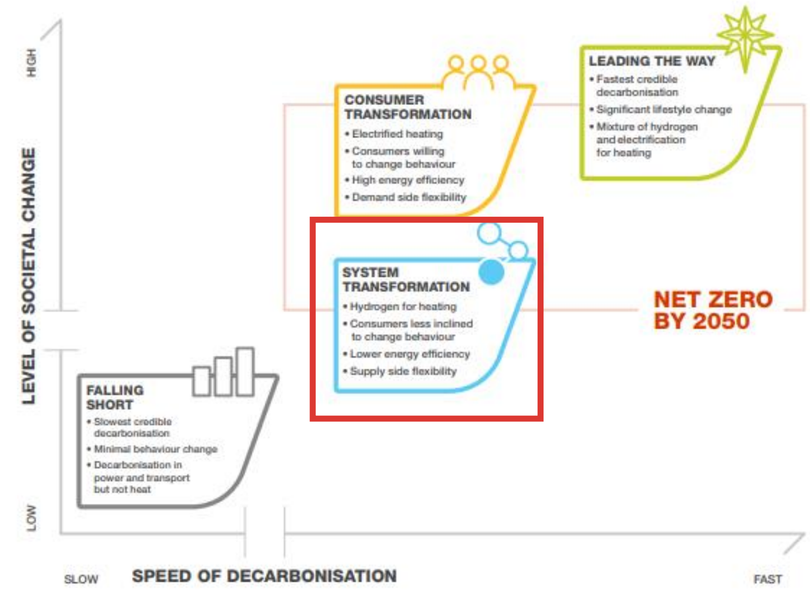
Modelling of the different options with the split of demand and supply between the different platforms differs and is described in the introduction to each option.

We use a Net Zero scenario across Europe as the market fundamentals in our study

We use the following scenario for market fundamentals:
- FES 22 scenario ‘System Transformation’ – “ST” for UK demand, capacity and interconnections
- TYNDP 22 scenario ‘Global Ambition’ – “GA” for the rest of Europe (demand and capacity)
- TYNDP 22 scenario “CBA Reference Grid” for the rest of Europe (interconnections)
- WEO 22 scenario ‘Announced Pledges’ for commodity prices.

This ensure a consistent scenario across Europe reflecting countries commitment to reach net zero emissions in 2050.

FES 22 “System Transformation”



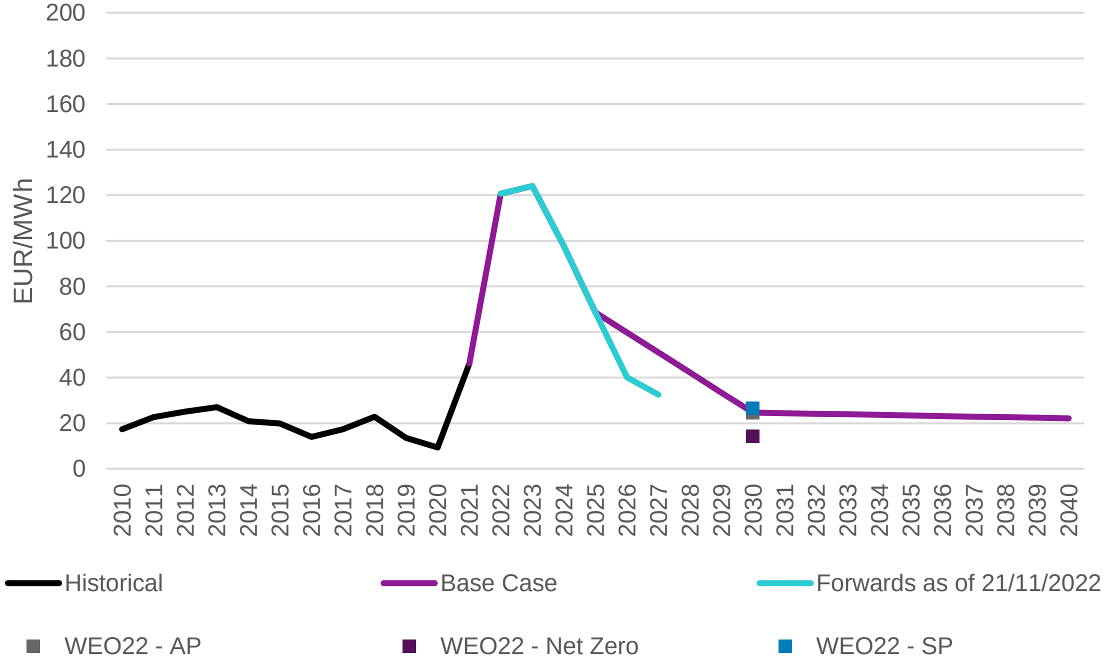
TYNDP 22 “Global Ambition”

	Distributed Energy Higher European autonomy with renewable and decentralised focus	Global Ambition Global economy with centralised low carbon and RES options
Green Transition	At least a 55 % reduction in 2030, climate neutral in 2050	
Driving force of the energy transition	Transition initiated at a local/national level (prosumers)	Transition initiated at a European/international level
	Aims for EU energy autonomy through maximisation of RES and smart sector integration (P2G/L)	High EU RES development supplemented with low carbon energy and imports
Energy intensity	Reduced energy demand through circularity and better energy consumption behaviour	Energy demand also declines, but priority is given to decarbonisation of energy supply
	Digitalisation driven by prosumer and variable RES management	Digitalisation and automation reinforce competitiveness of EU business
Technologies	Focus of decentralised technologies (PV, batteries, etc.) and smart charging	Focus on large scale technologies (offshore wind, large storage)
	Focus on electric heat pumps and district heating	Focus on hybrid heating technology
	Higher share of EV, with e-liquids and biofuels supplementing for heavy transport	Wide range of technologies across mobility sectors (electricity, hydrogen and biofuels)
	Minimal CCS and nuclear	Integration of nuclear and CCS

Figure 2: Storylines for the two COP21 scenarios

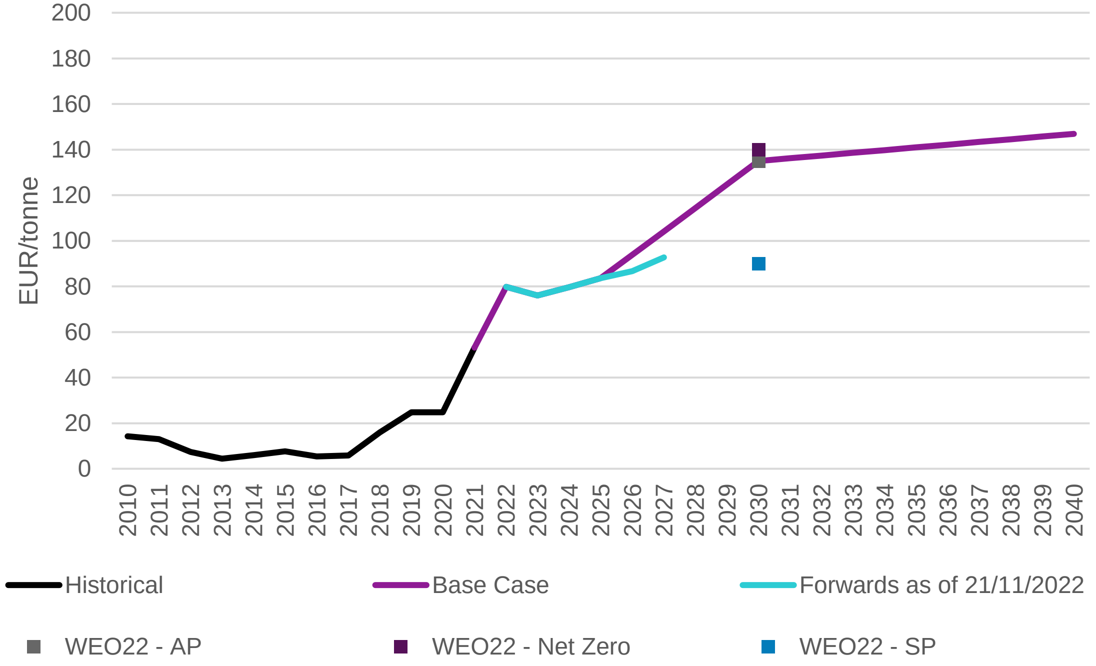
For commodity prices, we use forwards in the short term and WEO22 - Announced Pledges scenario in the long term

Gas price (EUR/MWh)



- For gas prices, we use **forwards in the short term (until 2025)** and **WEO22 - Announced Pledges scenario in the long term.**
- Forwards were extracted on 21 November 2022.

CO2 price (EUR/t)



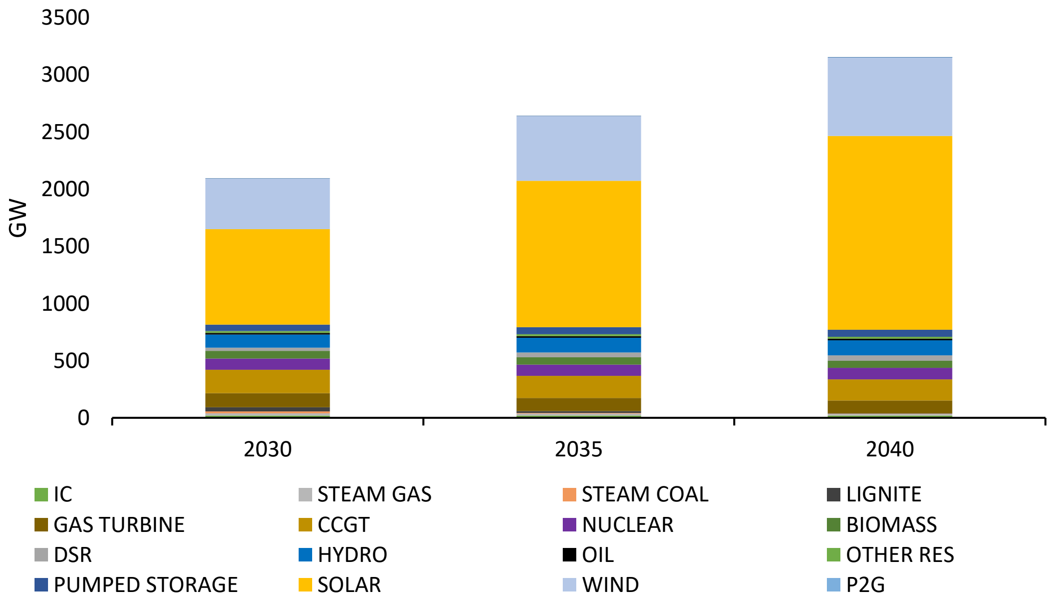
- For CO_2 prices, we use **forwards in the short term (until 2025)** and **WEO22 - Announced Pledges scenario in the long term.**
- Forwards were extracted on 21 November 2022.

Sources: CL analysis

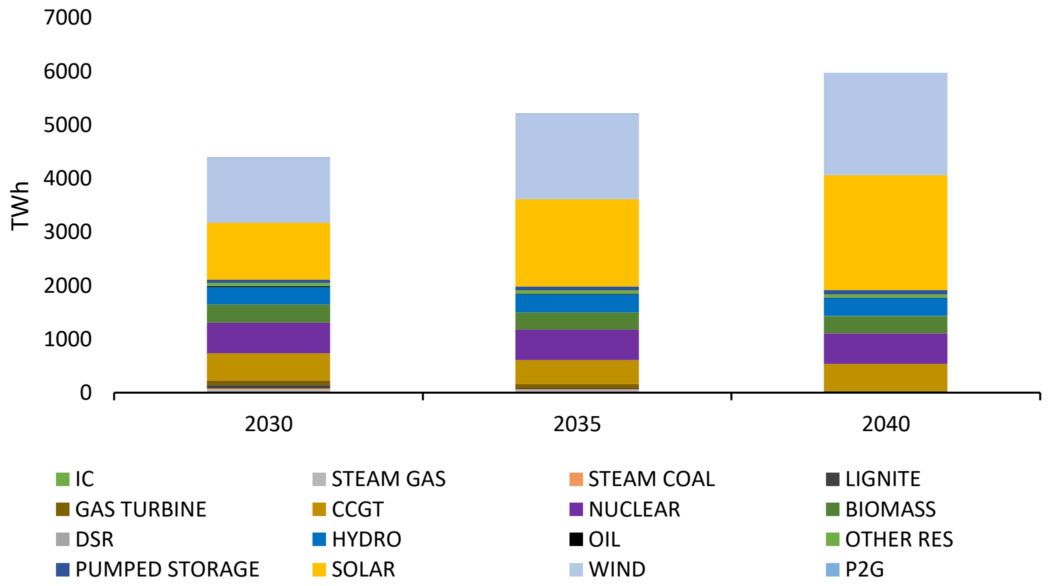
Capacity and generation mix outlook – EU 25

- Nuclear generation drops from 13% by 2030 to 11% by 2035 and 9% by 2040 in the gross electricity consumption mix. Meanwhile fossil fuel generation drops from 17% by 2030 to 12% by 2035 and 9% by 2040 in the gross electricity consumption mix respectively.
- RES generation in EU25* zone represents respectively **70%, 77% and 81%** of gross electricity consumption mix in 2030, 2035 and 2040.
- Most ambitious European targets are reach by 2030 (~65-70% of RES share in gross electricity consumption). In addition, the combination of nuclear and RES generation represent 83% of gross electricity consumption by 2030.

Capacity Mix – EU25 zone (GW)



Generation Mix – EU25 zone (TWh)

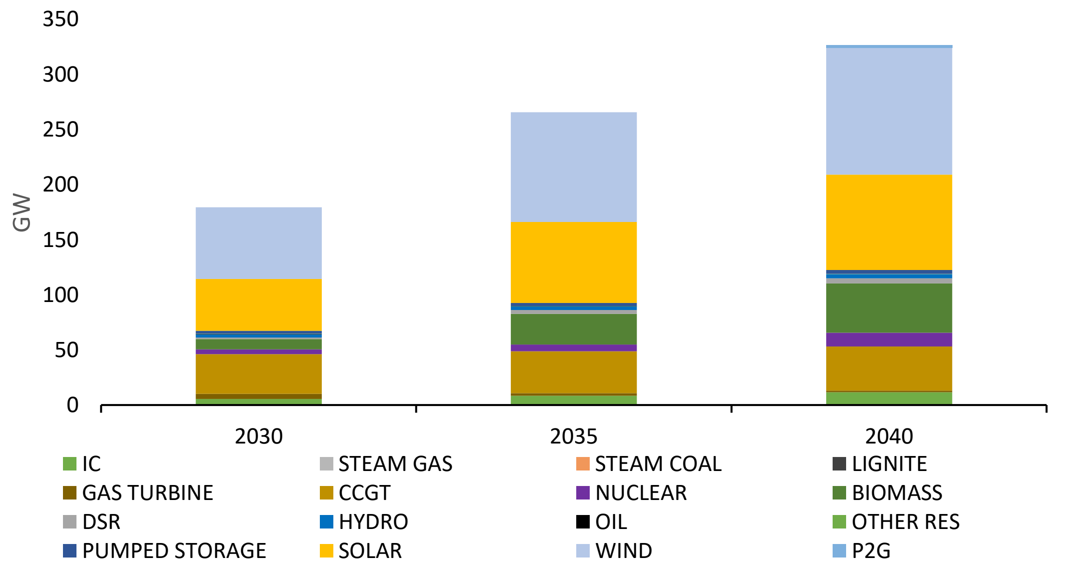


*: EU25 includes all EU countries except Malta and Cyprus.

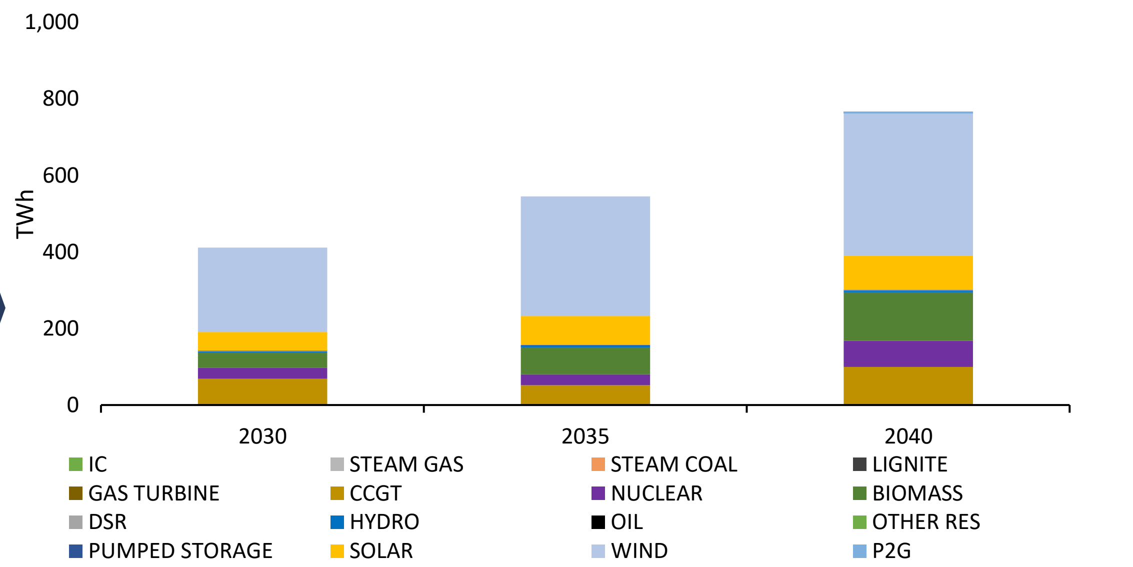
Capacity and generation mix outlook – GB

- Nuclear generation drops from 7% by 2030 to 5% by 2035 but increases to 9% by 2040 in the gross electricity consumption mix with the strong increase in demand. Meanwhile fossil fuel generation follows the same trend drops from 17% by 2030 to 10% by 2035 and 13% by 2040 in the gross electricity consumption mix respectively.
- RES generation in GB zone represents respectively **76%, 85% and 78%** of gross electricity consumption mix in 2030, 2035 and 2040.
- The combination of nuclear and RES generation represent 83% of gross electricity consumption by 2030.

Capacity Mix – GB (GW)



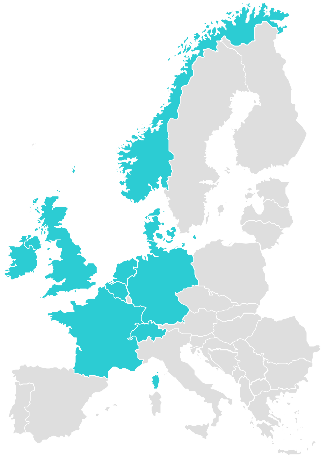
Generation Mix – GB (TWh)



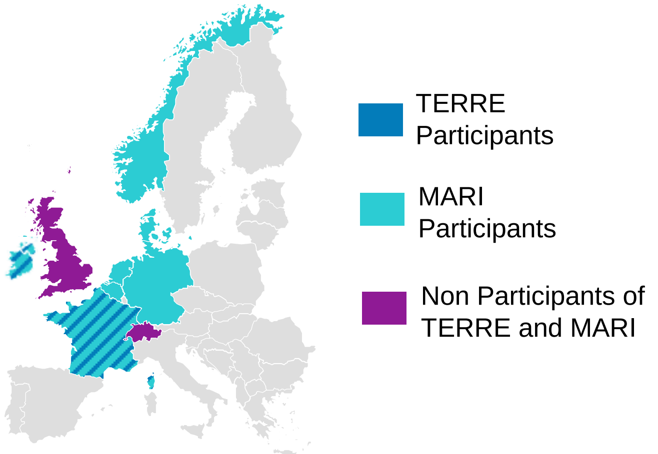
We focus on the countries interconnected to the UK, and Switzerland in the activation energy modelling step

Power market dispatch model

Capacity reservation market (upward mFRR and RR / downward mFRR and RR)



Energy activation market (upward mFRR and RR / downward mFRR and RR)



1 As a first step, we run the power market dispatch model on all European countries.

2 In a second step, we run our capacity reservation model on countries sharing interconnections with the UK (and also Switzerland).

3 In a third step, we run our activation model for MARI, TERRE and options for Cross-Border Balancing between GB, CH* and other European countries. In this phase, we take into account the results of the power model of phase 1 and the reserved capacity in phase 2.**

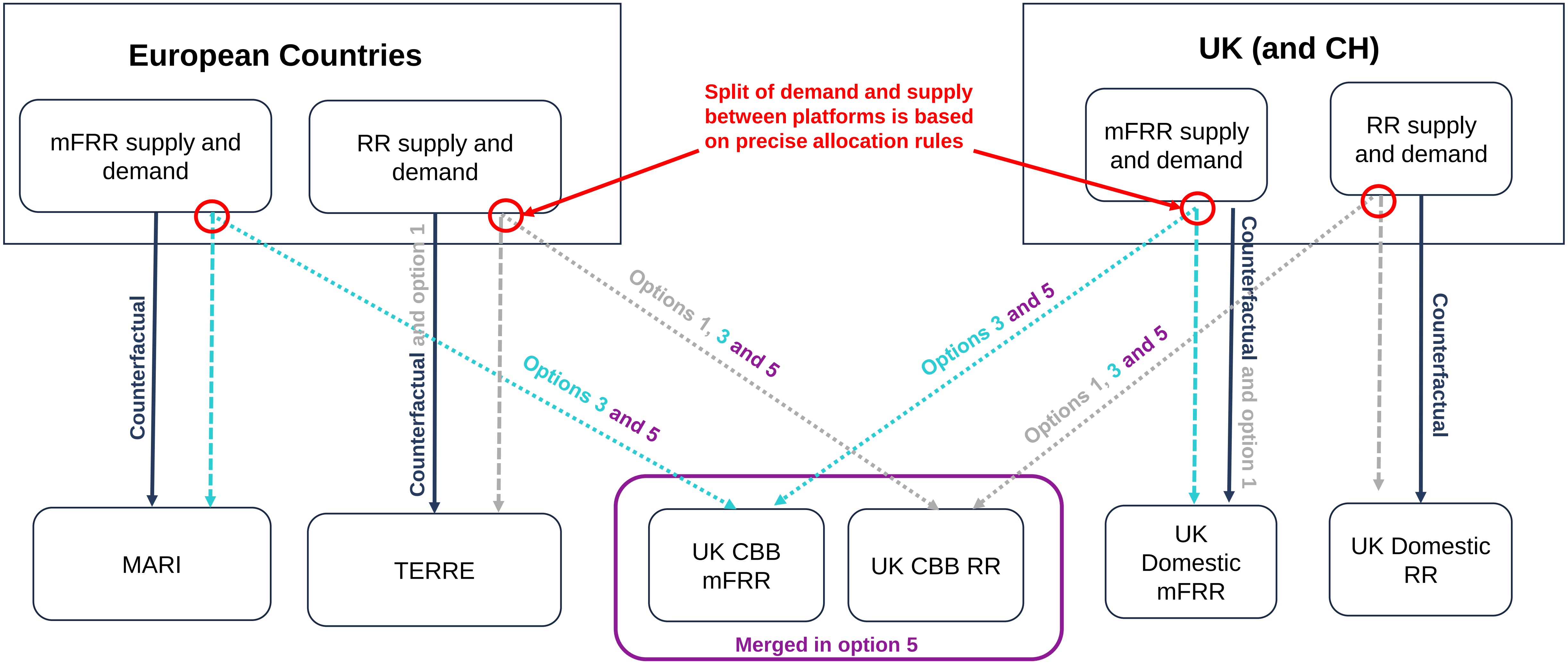
*: We considered that Switzerland would not be part of TERRE and MARI following the decisions of the European Commission, which indicated that it did not comply with the EBGL.

**: Ireland and Northern Ireland are currently not part of TERRE et MARI, but after discussion with Eirgrid, we were told that it was likely that these two bidding zones would integrate these platforms before 2030.

The comparison methodology and parametrisation of CBB options are key to assessing the value of these platforms

- **Value of options determined in delta versus a counterfactual**
  - To assess the value of the different options, we compare them to a counterfactual. **In the counterfactual, we assume that no trade is possible between GB (and CH) and the rest of Europe.** We therefore model independently the British domestic market, the Swiss domestic market, and the European platforms MARI and TERRE.
  - We model for the counterfactual and for each of the options: **upward mFRR, downward mFRR, upward RR and downward RR**. For each of these reserves, a reservation phase is also carried out beforehand. Downward mFRR and downward RR represent a revenue for the TSOs as the power plants buy back their electricity. These revenues are represented in negative on our cost graphs in the following presentation.
- **Split of demand and supply between UK CBB platform and other platforms**
- Sharing demand on platforms:
  - **We consider that only the peaks of demand will be shared on the UK CBB platforms**, the interest for TSOs being to seek cheaper offers on the UK CBB platforms only when the needs are important.
  - Therefore, we assume that countries **keep 85% of the demand on the internal platforms (the lowest in absolute terms)** and the rest is shared on the UK CBB platforms.
  - Furthermore, we do **not consider any optimisation or learning curve when using the platforms.**
  - The more technical view of demand sharing will be found in the body of the report.
- Sharing supply on platforms:
  - We **ensure that countries keep a substantial level of supply on their domestic platforms**, in particular to cover the 85% of demand remaining on their platforms. For this purpose, we assume that countries keep the cheapest supply.
  - The rest of the supply can be shared in part on the UK CBB platform, ensuring also that **at least all demand placed in the UK CBB platform must be offered in supply**.
  - The more technical view of demand sharing will be found in the body of the report.

Illustration of the methodology used to model the options



Note: -In the counterfactual and the options, trades between countries of the platforms are limited by the interconnection capacity available after the Day-Ahead market.

- In option 1, as the UK CBB platform is before TERRE, it allows to replace the supply not selected in the UK CBB in TERRE and to have nuclear bids.

Summary of the modelling of the different options

Option 1

- **mFRR** : UK domestic market, CH domestic market and MARI completely **independent**
- **RR** :
  - UK CBB platform: participation of UK and modelled countries with RR. The existence of this platform ahead of TERRE allows the nuclear to be able to make offers on this market.
  - UK domestic market: only UK with demand and supply **not selected** on the UK CBB market (same for Switzerland).
  - TERRE: the other European countries modelled (excluding the UK and CH) with demand and supply **not selected** on the UK CBB market.

Option 3

- **mFRR:**
  - UK CBB platform: participation of UK and European modelled countries.
  - UK domestic market: only UK with demand and supply **not placed** on the UK CBB market (same for Switzerland).
  - MARI: the other European countries modelled (excluding the UK and CH) with demand and supply **not placed** on the UK CBB market.
- **RR**:
  - UK CBB platform: participation of UK and modelled countries with RR.
  - UK domestic market: only UK with demand and supply **not placed** on the UK CBB market (same for Switzerland).
  - TERRE: the other European countries modelled (excluding the UK and CH) with demand and supply **not placed** on the UK CBB market.

Option 5

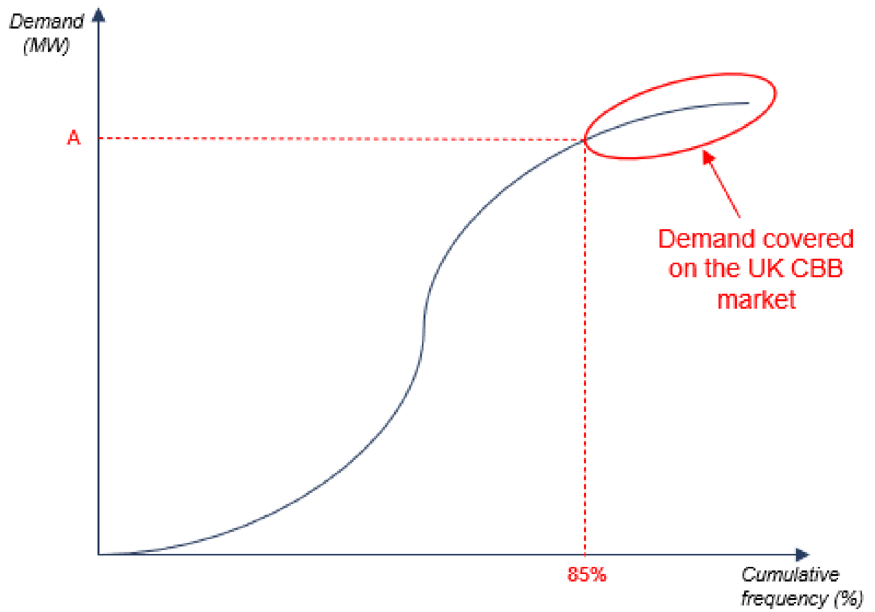
- **mFRR / RR**:
  - UK CBB platform: participation of UK and other European modelled countries. **Data for mFRR and RR are merged.**
  - UK domestic market: only UK with demand and supply **not placed** on the UK CBB market.
  - MARI-TERRE: the other European countries modelled (excluding the UK and CH) with demand and supply **not placed** on the UK CBB market.

Note: In each of the options, trade between countries is limited by the interconnection capacity available after the Day-Ahead market.

Modelling the split of demand and supply between UK CBB platform and other platforms (UK domestic market, MARI or TERRE)

Demand

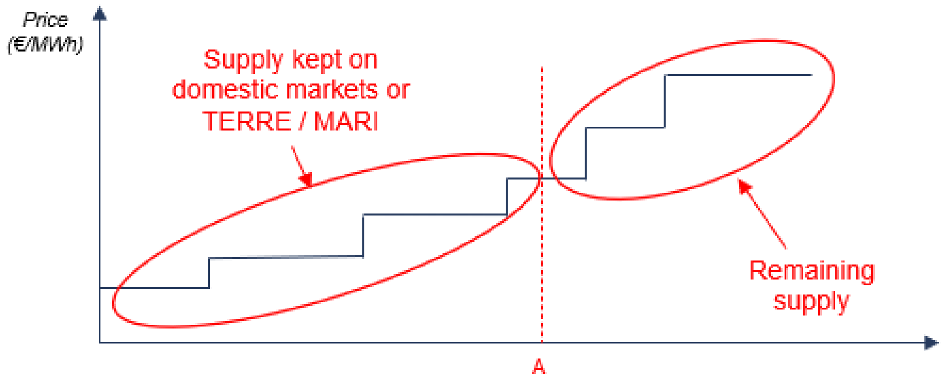
Cumulative demand over the year:



Note: All demand above A is placed on the UK CBB platform, we do not consider any optimisation or learning curve when using the platforms.

Supply

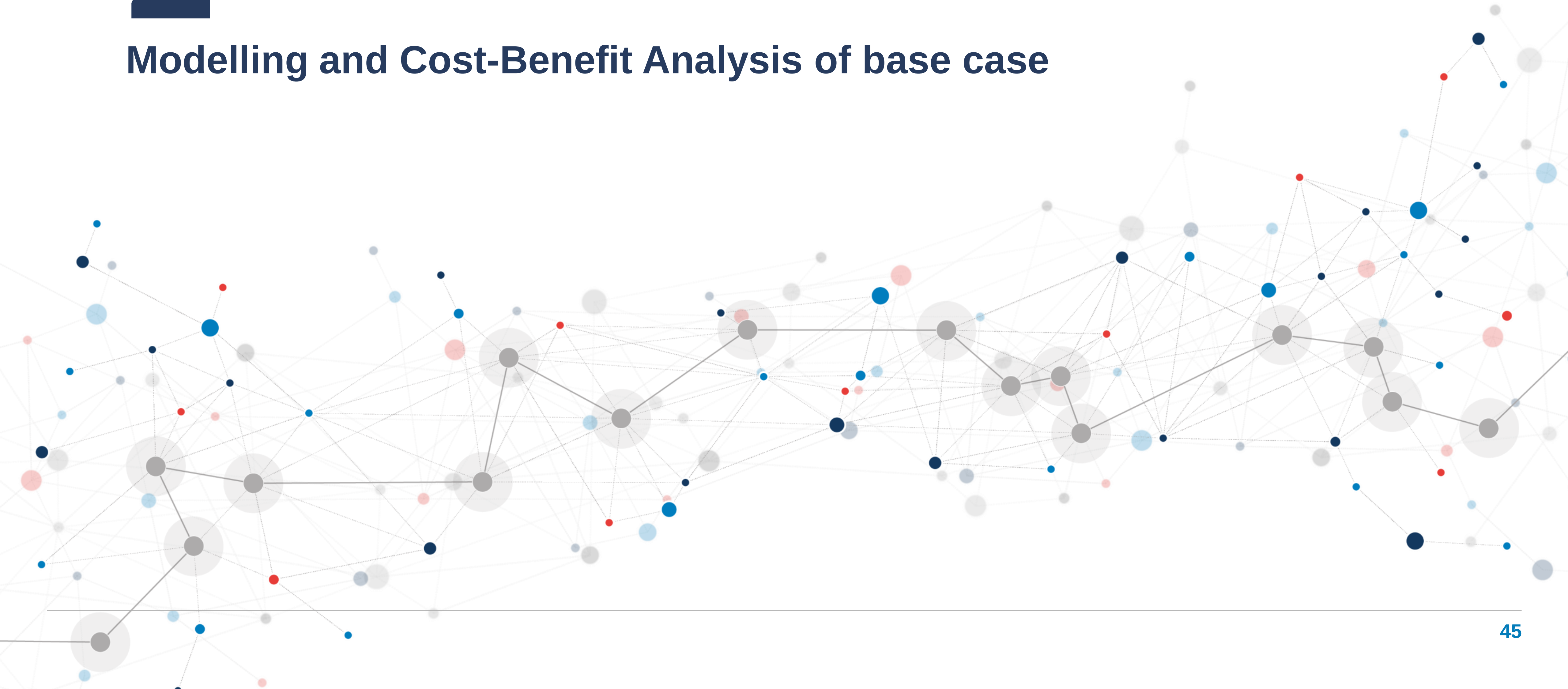
1. Countries keep the cheapest supply that allows them to cover its demand in 85% of the hours when there is activation.
   - This supply for the UK (and CH) would be placed on their domestic markets.
   - This supply for the other European countries would be placed on MARI or TERRE.
2. For the remaining supply:
   - The remaining supply on the UK (and CH) side would be fully placed on UK CBB market
   - The remaining supply on the other European countries would be split between the 2 CB markets (30% on UK CBB market and 70% in MARI or TERRE)



Note: At least all demand in the UK CBB platform must be offered in supply.

2

Modelling and Cost-Benefit Analysis of base case



2.1

Modelling and Cost-Benefit Analysis of base case

1. Counterfactual – No cross-border balancing exchanges

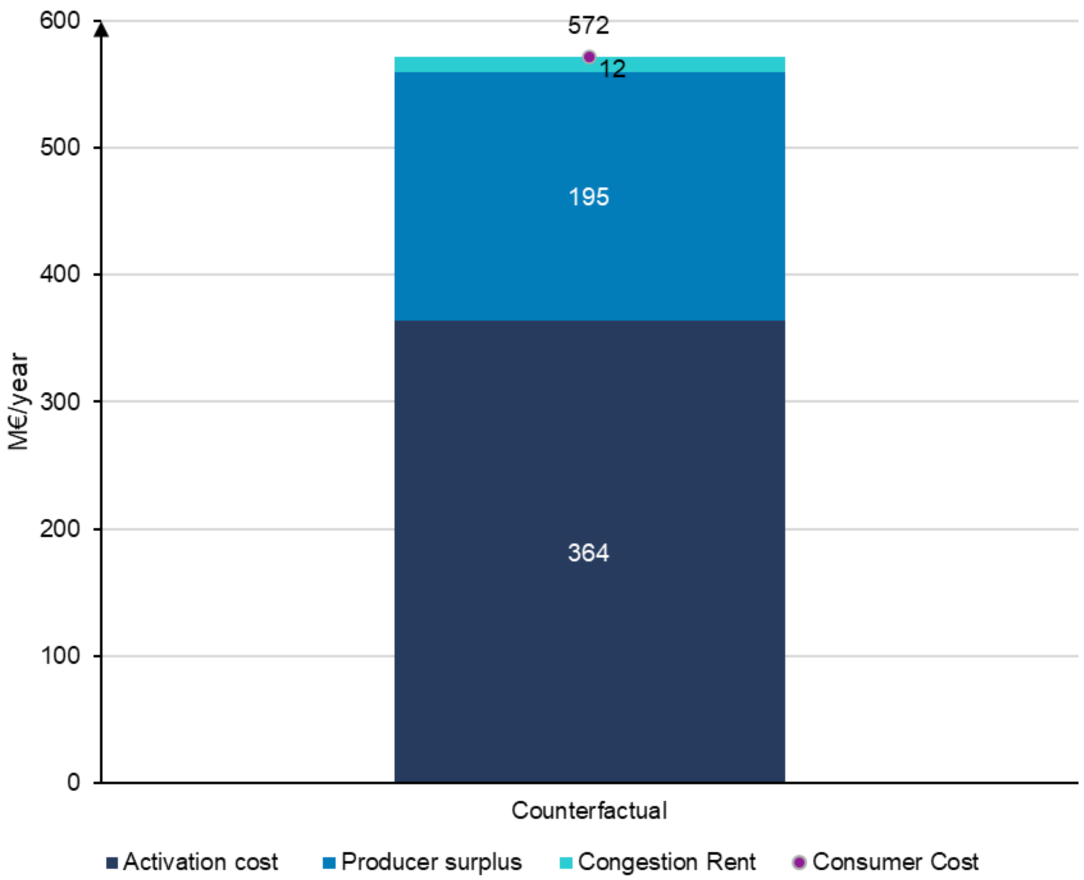
Counterfactual – No cross-border balancing exchanges

- **mFRR**:
- All European countries share their mFRR bids and mFRR demands on MARI.
- UK and Switzerland meet their demand with national bids only.

- **RR**:
- European countries (France and Ireland) share their RR bids and RR demands on TERRE.
- UK and Switzerland meet their demand with national bids only.

In the counterfactual, the activation cost is 364M€ and the consumer cost is 572M€

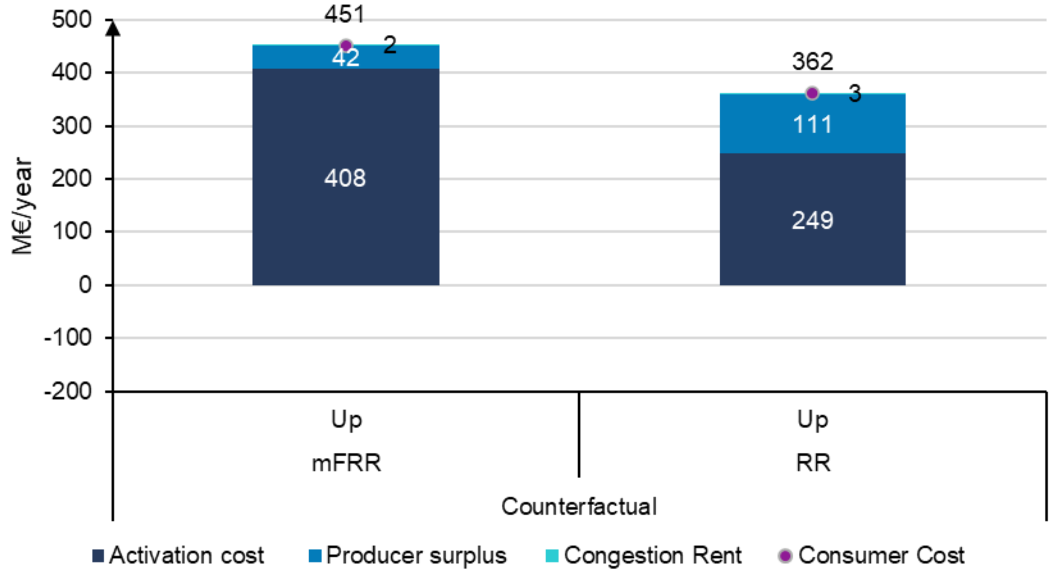
Consumer costs split by type for mFRR + RR – 2030 – counterfactual



- **Indicators**:
- Activation cost:
  - Represents the sum of the activation costs of power plants over all modelled countries. It incorporates upward mFRR and RR and downward mFRR and RR. In downward mFRR and RR, power plants buy back their electricity from the TSO most of the time and these TSO revenues are therefore deducted from the upward mFRR and mFRR activation costs on this graph.
  - **The difference of activation costs between counterfactual and options represents the most relevant economic surplus generated.**
- Producer surplus:
  - represents the difference of the price received by plants and their activation costs (or the maximum price at which power plants would have been willing to buy their electricity in downward mFRR and RR) over all modelled countries.
- Congestion rent:
  - represents the rent from price differences between countries arising from limited interconnection capacity
- Consumer cost:
  - represents the cost paid by the final consumer (represented by the TSO), i.e. the load multiplied by the price paid for each of the countries modelled (deducted from revenues in downward mFRR and RR when the plants bought back their electricity)
  - It is the sum of the three previous indicators.

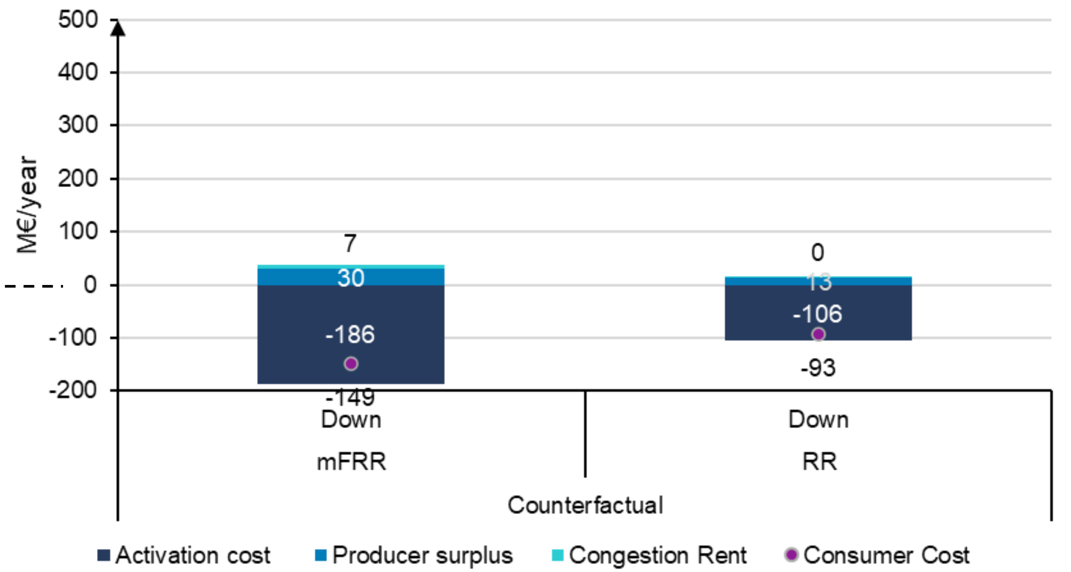
Overall, revenues received by the TSO in downward mFRR and RR only partially offset the costs in upward mFRR and RR

Consumer costs split by type for mFRR + RR Up – 2030 – Counterfactual



- **Upward mFRR consumer costs are higher than those of upward RR** in absolute terms because of the higher demand for upward mFRR (as many countries have mFRR but no RR).
- However, the producer surplus is higher in upward RR, in a market where prices can soar more often because there is less supply available.

Consumer costs split by type for mFRR + RR Down – 2030 – Counterfactual



- **Revenues from downward mFRR costs are higher than those of downward RR** in absolute terms because of the higher demand for downward mFRR (as many countries have mFRR but no RR).
- As prices in downward mFFR and RR are lower than those in upward mFRR and RR, producer surpluses are lower in upward mFRR and RR.
- Overall, **revenues received by the TSO in downward mFRR and RR only partially offset the costs in upward mFRR and RR.**

In the counterfactual, the Netherlands and Nordic countries are major exporters while Germany and France are major importers

Net interchange of balancing energy (GWh)

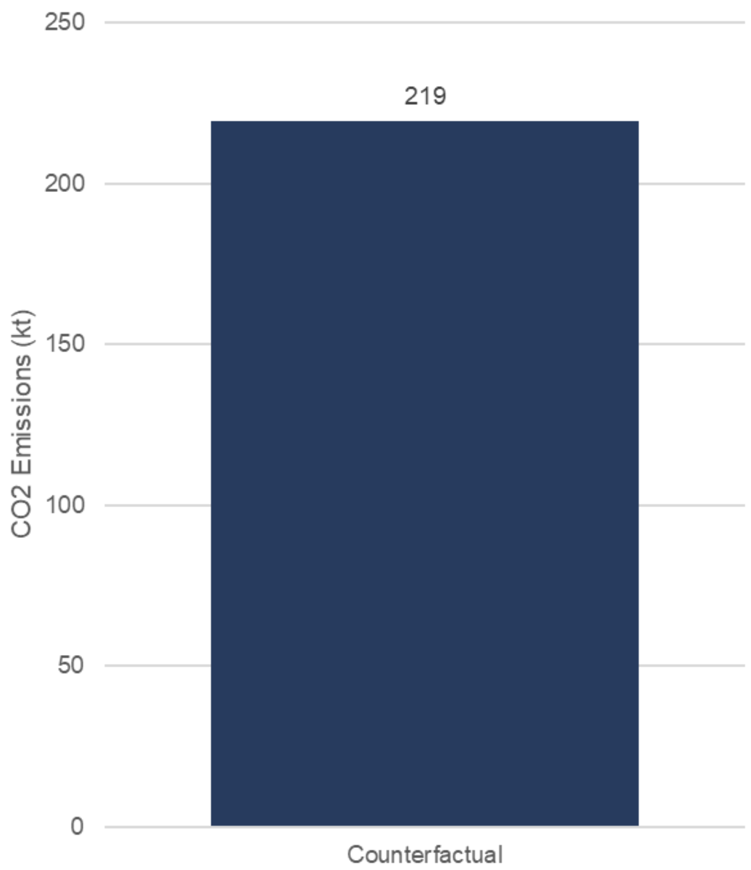
Net export (GWh)	mFRR		RR		Total
	Down	Up	Down	Up	
BE	160	-109	0	0	52
CH	0	0	0	0	0
DE	-222	-91	0	0	-313
DK	-13	149	0	0	136
FR	-267	-93	-50	-25	-434
GB	0	0	0	0	0
IE + NI	-5	-28	50	25	41
NL	318	10	0	0	327
NO	28	161	0	0	189

Up: Net interchange of upward balancing energy (>0: net exporter, <0: net importer)
Down : Net interchange of downward balancing energy. For downward energy, >0 means a net exporting position of downward energy, i.e. in practice the concerned country is importing energy.

- For upward mFRR:
  - **Germany, France and Belgium are net importers of upward balancing energy**. France is a major importer because it has a large demand and Germany is a major importer because the price bids offer by its supply in mFRR activation are high.
  - **Norway and Denmark (and the Netherlands to a limited extent) are net exporters of upward balancing energy**. Norway is a net exporter thanks to the export of its hydro which offers large volumes at a competitive price.
- For downward mFRR:
  - **Germany, France and Denmark are net importers of downward balancing energy**. France is a major importer of downward balancing energy because it has a large demand and Germany is a major exporter because the price bids offer by its supply to buy back their electricity in mFRR activation are low in absolute.
  - **The Netherlands is a major balancing energy provider, together with Norway and Belgium**. The Netherlands is a net exporter because it has little demand but has supply available for export.
- For upward RR:
  - The majority of the demand for upward RR is in France, resulting in **flows go predominantly from Ireland to France**
- For downward RR:
  - The majority of the demand for downward RR is in France, **resulting in France importing downward balancing energy from Ireland.**

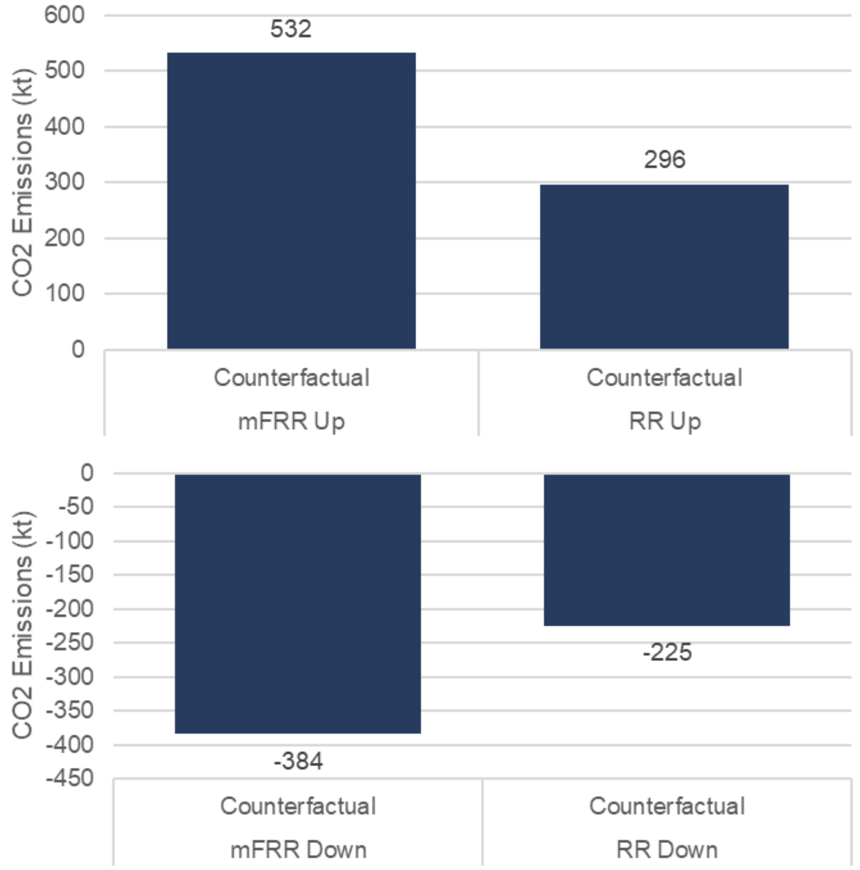
In the counterfactual, net CO2 emissions from the mFRR / RR activation are positive, mainly with the emissions from the upward mFRR

CO2 emissions – Counterfactual – mFRR + RR - 2030



- **Net CO2 emissions from the mFRR / RR activation are positive,** mainly with the emissions from the upward mFRR. Downward activation of mFRR and RR, conversely, reduces net emissions.
- **Upward mFRR CO2 emissions are higher than those of upward RR** in absolute terms because of the higher demand for upward mFRR (as many countries have mFRR but no RR).
- Similarly downward mFRR reduces more CO2 emissions than RR due to higher demand.

CO2 emissions – Counterfactual – Up and Down - 2030



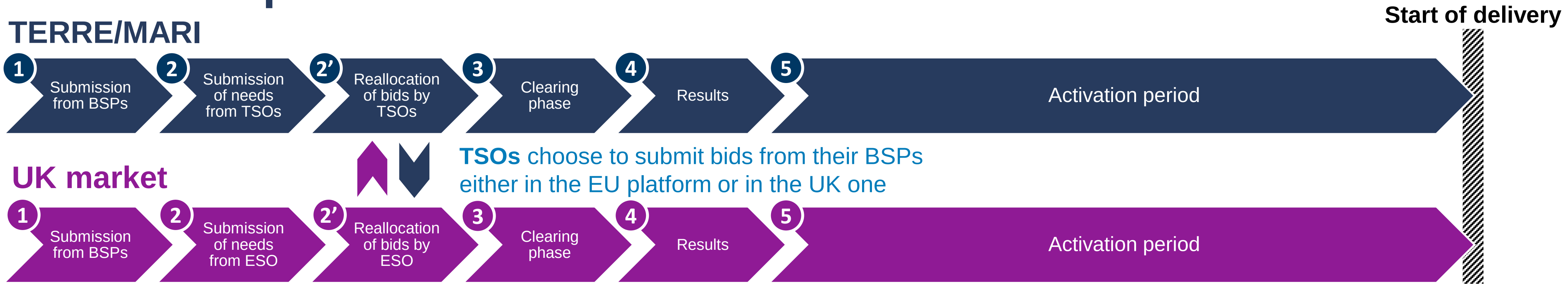
Note: CO2 emissions for downward mFRR and RR are represented in negative because the downward activation corresponds to a decrease in production, thus a reduction in emissions for thermal power plants.

2.2

Modelling and Cost-Benefit Analysis of base case

2. Option 3 – Parallel markets – SO allocation

Option 3: EU TSOs and NGESO choose to offer/demand balancing between 2 parallel markets



Functioning: TSOs have the possibility to reallocate the local bids depending on their anticipations

1. Submission of bids: Parallel. BSPs submit their bids on the local markets with similar deadlines.

2. Submission of needs: Parallel. TSOs submit their needs on the different platforms that are available to them.

2' Reallocation of bids: Parallel. TSOs choose on which market to submit bids from their BSPs (or can place reshaped bids).

3. Clearing/activation: Parallel. The clearing & activation are done independently on each platform.

Key concerns

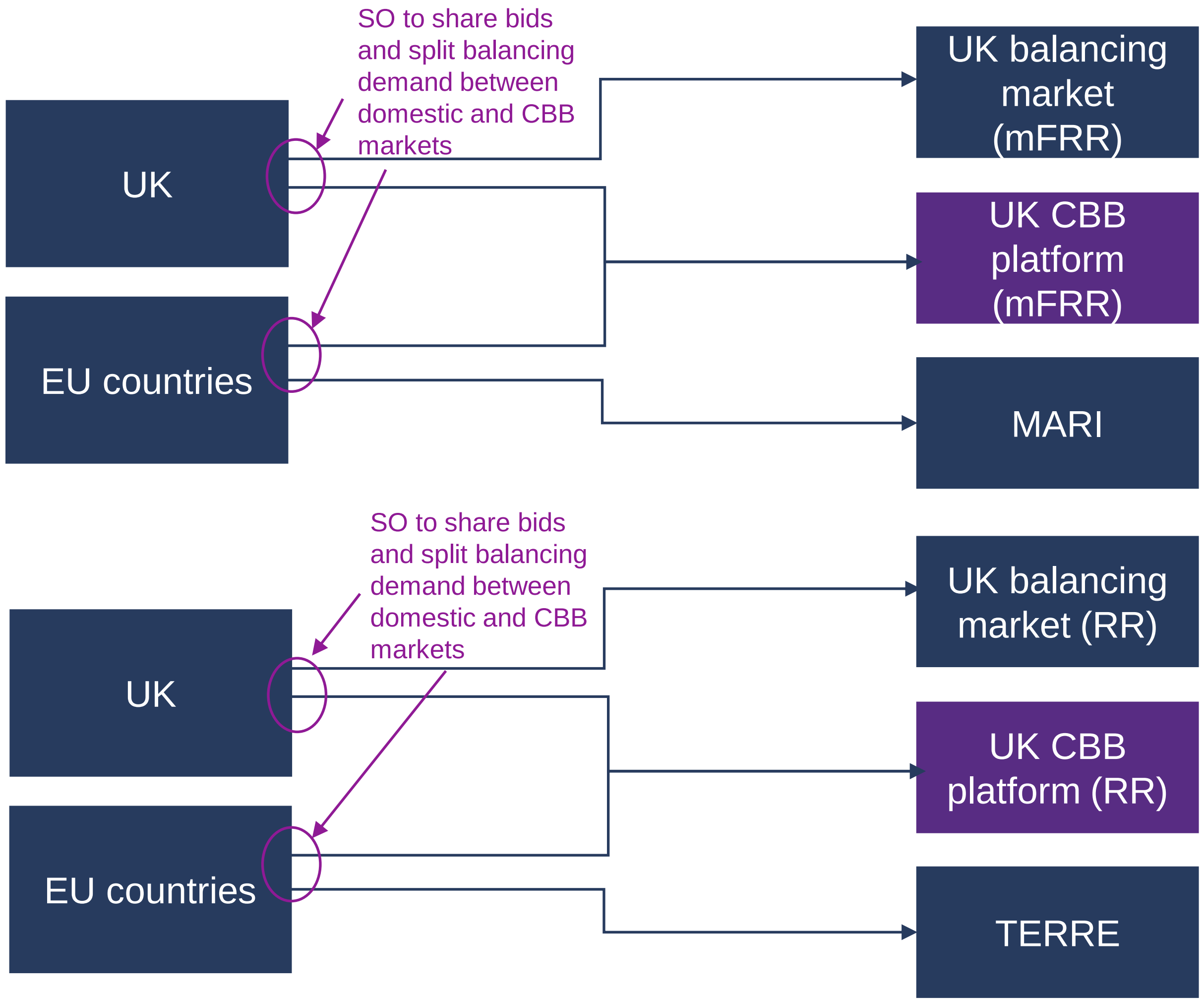
If there is no national market (e.g. RR in Germany), TSOs have no bids to allocate.

TSOs would need to split their demand without guarantees to get volumes. Could be problematic, especially for mFRR.

TSOs may only need part of a bid for their local market, while the rest could be useful to the other market:

- Option 3A: TSOs only reallocate bids.
- Option 3B: TSOs may allocate reshaped bids to TERRE/MARI or to the GB market (e.g. separate capacity of a divisible offer).

Option 3 – CBB platforms with UK in parallel of EU platforms



- **<u>mFRR</u>**:
- UK CBB platform: participation of UK and European modelled countries. Demand and supply of the different participants according to the principle stated in next slide.
- UK domestic market: only UK with demand and supply not placed on the UK CBB market.
- MARI: the other European countries modelled (excluding the UK and CH) with demand and supply not placed on the UK CBB market.

<u>NB</u>: Switzerland is modelled in a similar way to Great Britain: participation in the UK CBB platform and domestic market (no participation in MARI).

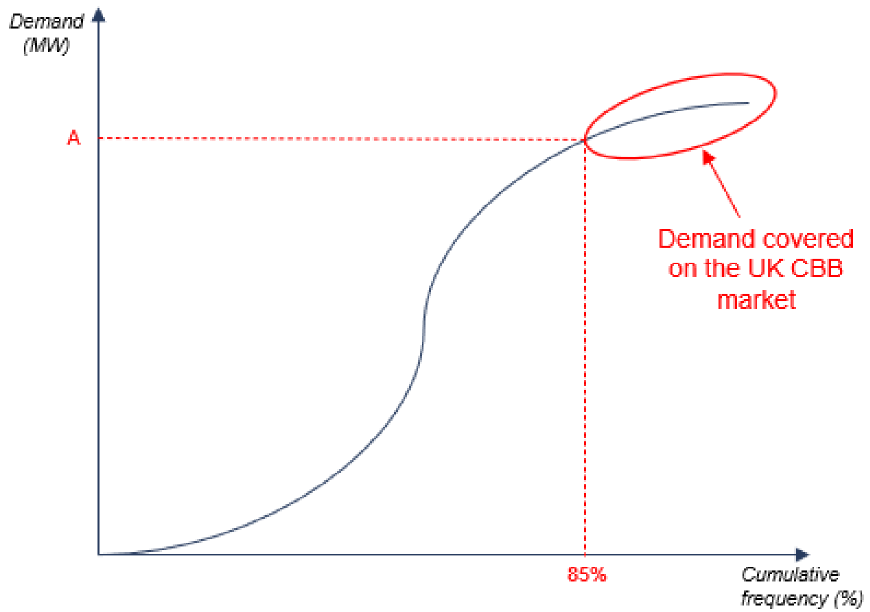
- **<u>RR</u>**:
- UK CBB platform: participation of UK and modelled countries with RR. Demand and supply of the different participants according to the principle stated in next slide.
- UK domestic market: only UK with demand and supply not placed on the UK CBB market
- TERRE: the other European countries modelled (excluding the UK and CH) with demand and supply not placed on the UK CBB market.

<u>NB</u>: Switzerland is modelled in a similar way to Great Britain: participation in the UK CBB platform and domestic market (no participation in TERRE).

Modelling the split of demand and supply between UK CBB platform and other platforms (UK domestic market, MARI or TERRE)

Demand

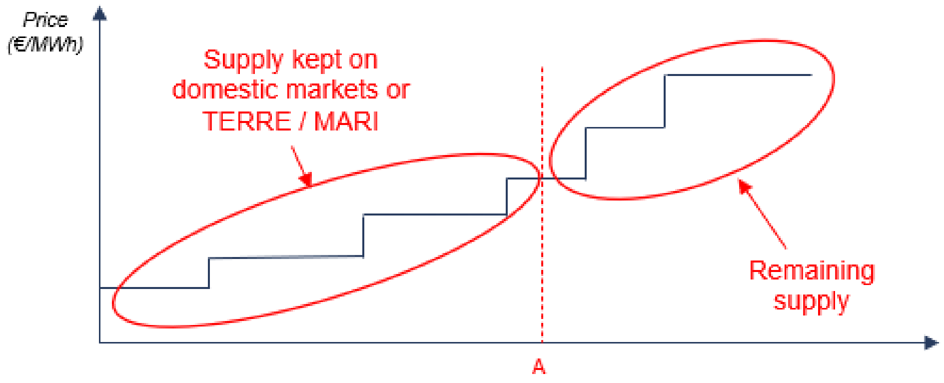
Cumulative demand over the year:



Note: All demand above A is placed on the UK CBB platform, we do not consider any optimisation or learning curve when using the platforms.

Supply

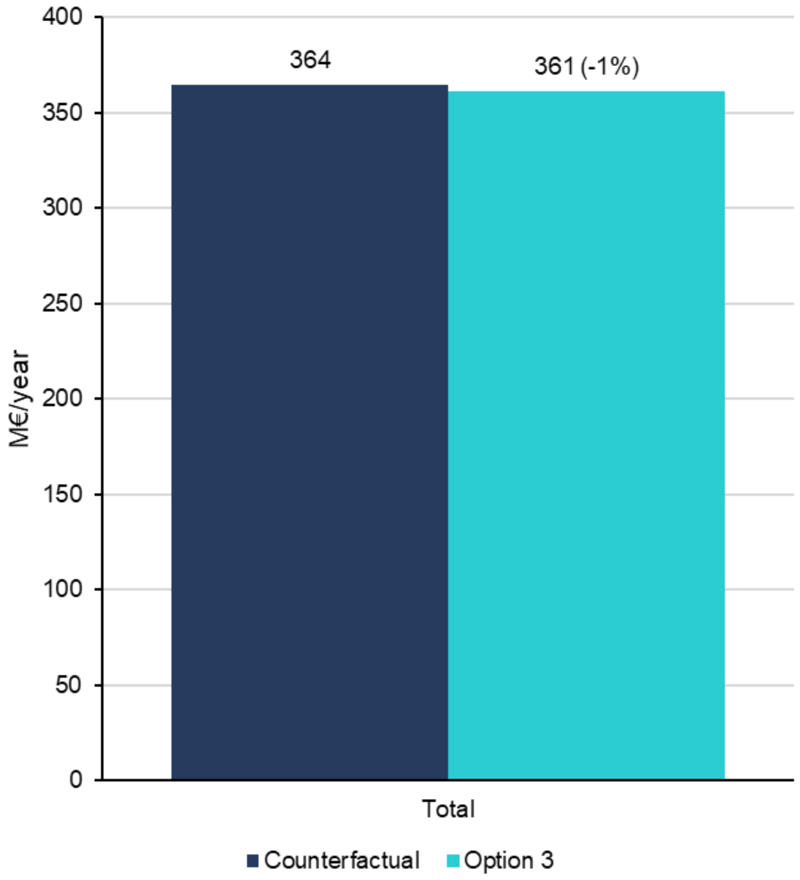
1. Countries keep the cheapest supply that allows them to cover its demand in 85% of the hours when there is activation.
   - This supply for the UK (and CH) would be placed on their domestic markets.
   - This supply for the other European countries would be placed on MARI or TERRE.
2. For the remaining supply:
   - The remaining supply on the UK (and CH) side would be fully placed on UK CBB market
   - The remaining supply on the other European countries would be split between the 2 CB markets (30% on UK CBB market and 70% in MARI or TERRE)



Note: At least all demand in the UK CBB platform must be offered in supply.

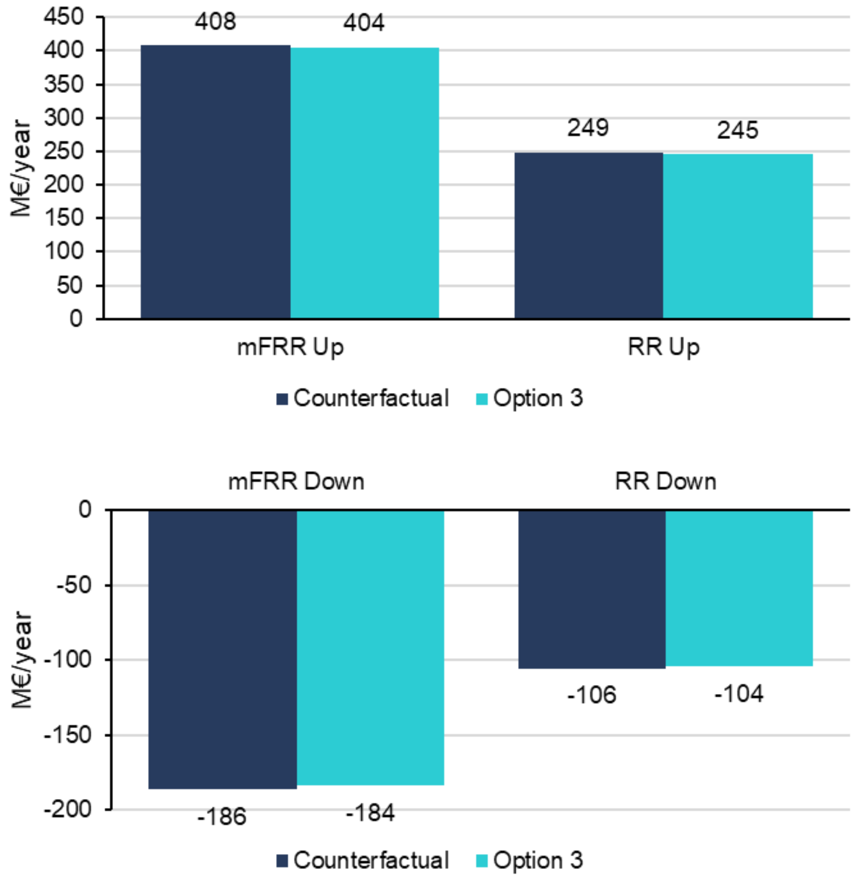
Activation cost in option 3 is slightly lower than in the counterfactual

Activation cost – Option 3 – mFRR + RR - 2030



- **The activation cost in option 3 is slightly lower than in the counterfactual,** mainly due to lower activation costs in upward mFRR and RR.
- In downward mFRR and RR, option 3 allows for lower revenues than the counterfactual with the assumptions made. Indeed, it may happen that too much demand is placed on UK CBB platform compared to the proposed supply because of fixed allocation rules of bids and demand – see next slide for more details.
- This can also happen at certain times in upward mFRR and RR with an increase in costs, even if overall the platform leads to a decrease in costs.

Activation cost – Option 3 – Up and Down - 2030



Caveat: These results are obtained with the sharing and participation strategies as defined with NGESO. They do not include any optimization or learning curve when using the platforms.

With the assumptions made, the UK CBB platform sometimes leads to higher prices paid and higher activation costs

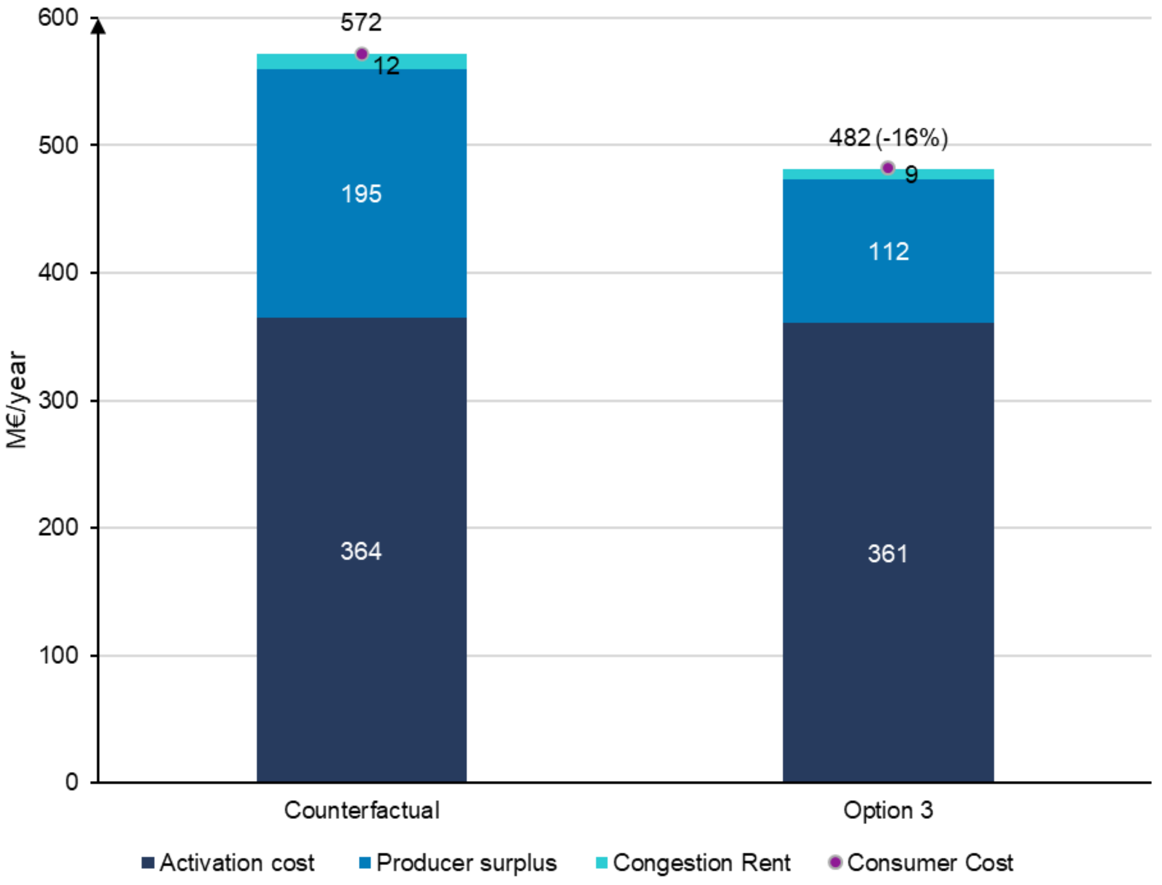
Example illustrating the higher activation cost in option 3 than in the counterfactual

RR Up - 8/17/2030 4:00:00 PM	Counterfactual		Option 3			
	FR - TERRE	**GB - Domestic**	**FR - TERRE**	**FR - UK CBB**	**GB - UK CBB**	**GB - Domestic**
Price (€/MWh)	113	0	113	155	155	0
Demand (MWh)	1101	0	900	201	0	0
Generation (MWh)	1101	0	900	92	109	0
Consumer Cost (k€) – similar in this example at the activation cost	124		133			

- In the counterfactual, France can meet all its demand of 1100 MW at a price of 113€/MWh with hydro and thermal units.
- In option 3, France keeps 900MW of supply (the "A" demand which corresponds to the 85% demand limit). For the rest of the supply, it puts 30% on UK CBB and keeps 70% for TERRE. With this split, there is only 80MW available on the UK CBB at a price of €113/MWh.
- However, the load placed on the UK CBB is 201 MW, so it will be necessary to activate plants at a high price, especially in Great Britain.
- In practice, this additional cost will induce a learning effect with a different sharing of bids and demand, which is complicated to model.
- This also shows that too much demand is shared on the UK platform compared to the proposed supply because of fixed allocation rules of bids and demand.
- **In practice, it is likely that EU TSOs will place lower / no demand on the UK CBB platforms**, reducing loss in surplus compared to the counterfactual.

The demand breakdown in option 3 leads to a significant decrease in consumer costs compared to the counterfactual

Consumer costs split by type for mFRR + RR – 2030 – Option 3



- **Option 3 leads to a significant reduction** of consumer costs, because of **the rules for allocating demand between UK CBB and TERRE / MARI platforms and to price formation.**
- Indeed, the **reduction of demand in EU platforms** (and UK domestic markets) together with the sharing of the less expensive offers lead to a price reduction in the EU platforms, hence applied to large volume. This **reduction in prices in these platforms largely exceeds the similar or slightly higher prices in the UK CBB platform**.
- In addition, **TSOs may also adapt the post-processing of the selection of the bids and their pricing**, that may impact the split of costs and benefits between producers and consumers.
- The modelling of this option also relies on several important assumptions about the sharing of supply and demand:
  - (i) on the ability to share supply on the EU side as producers from countries participating in TERRE / MARI have a legal obligation to place all their supply on these platforms, so it would require a regulatory change for this supply to be placed on the UK CBB platform;
  - (ii) on the sharing strategy implemented in practice by TSOs: the learning effect is not taken into account, as sharing may lead to inefficiencies, TSOs and producers would adjust their strategy (e.g. by putting less demand, or at very specific times)

Illustration of the demand breakdown leading to a significant decrease in consumer costs compared to the counterfactual

Load / Price / Consumer Cost – France and GB – Counterfactual vs Option 3 - Upward RR - 2030

	Counterfactual		Option 3			
	FR - TERRE	UK – Domestic Market	FR - TERRE	FR – UK CBB	UK – Domestic Market	UK – UK CBB
Load (GWh)	1739	6.5	1479	260	5	1.5
Average annual price (€/MWh)	188	153	132	220	146	131
Load-weighted average price (€/MWh)	188	153	145		143	
Consumer Cost (M€)	327	1.0	252		0.9	

- To illustrate the impact of the demand breakdown on the consumer cost, we use the example of the upward RR in option 3 in 2030 for France and Great Britain.
- In France, we see that the **reduction of demand in TERRE** together with the sharing of the less expensive offers lead to a price reduction in TERRE (from 188€/MWh to 132€/MWh), hence applied to large volume (1479GWh). This **reduction in prices largely exceeds the slightly higher prices for France in the UK CBB platform (220€/MWh)**. In the end, the reduction in consumer cost for France is very significant (from 327M€ to 252M€). Higher price in France in UK CBB platform was explained with more details in previous slide
- For Great Britain, we see that the **reduction in demand on its domestic market together with the sharing of the** less expensive offers **leads to a reduction in prices on its domestic market (from 153€/MWh to 146€/MWh).** This price reduction also appears on the UK CBB platform (132€/MWh).

In option 3, GB is a net importer and a transit place between Norway and the EU in mFRR, and a net exporter in RR

Net interchange of balancing energy (GWh)

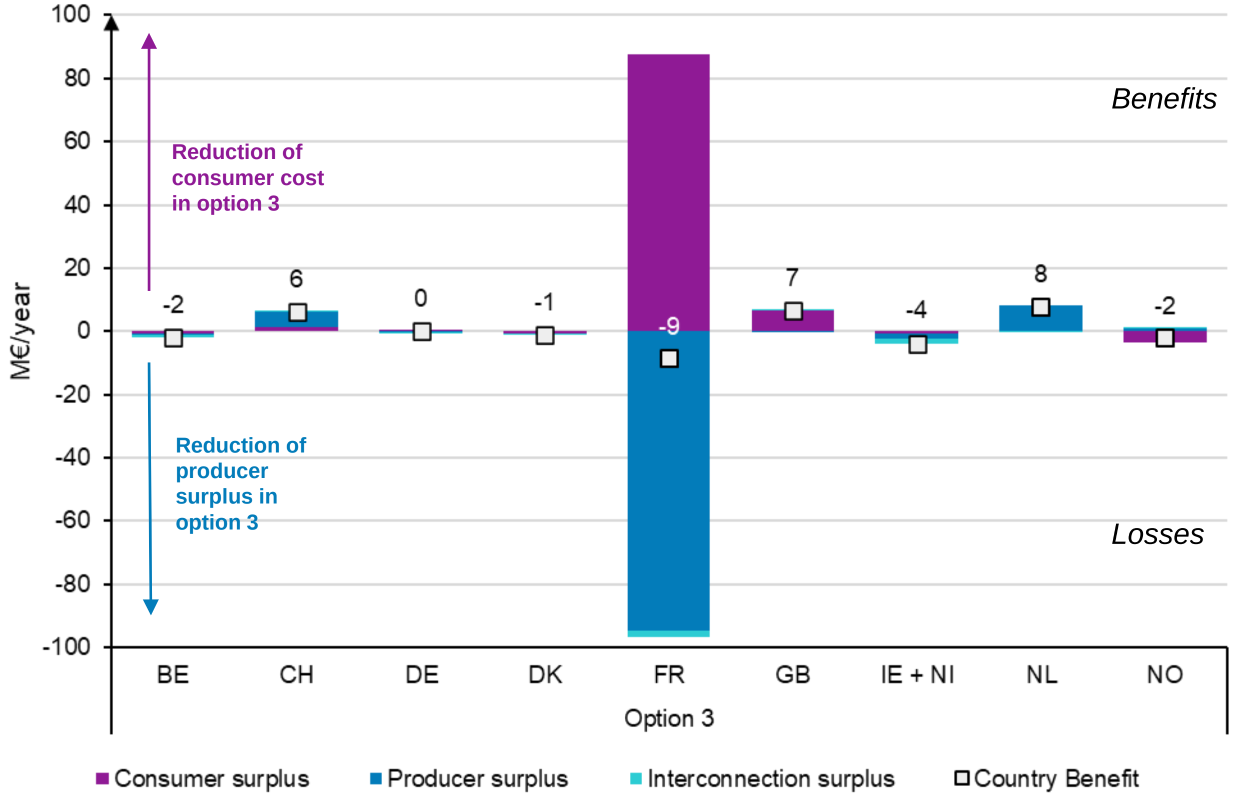
Net export (GWh)	mFRR		RR		Total
	Down	Up	Down	Up	
BE	107	-135	0	0	-28
CH	22	106	9	108	246
DE	-220	-117	0	0	-337
DK	-15	124	0	0	109
FR	-252	-162	-144	-174	-732
GB	-4	-52	96	83	124
IE + NI	-5	-37	39	-18	-21
NL	294	4	0	0	298
NO	74	268	0	0	342

Up: Net interchange of upward balancing energy (>0: net exporter, <0: net importer)
Down : Net interchange of downward balancing energy. For downward energy, >0 means a net exporting position of downward energy, i.e. in practice the concerned country is importing energy.

- For upward mFRR:
  - **GB, Germany, France and Belgium are net importers of upward balancing energy.** France and GB are major importers because of their large demands and Germany is a major importer because the price bids offer by its supply in mFRR activation are high.
  - **Norway is a major provider of upward balancing energy, together with Denmark and Switzerland to a lesser extent.** Norway exports a lot of balancing energy to GB, but GB is also as a transit country for Norway to export more balancing energy to the rest of Europe.
- For downward mFRR:
  - **Germany and France are net importers of downward balancing energy**. France is a major importer of downward balancing energy because of its large demand.
  - **The Netherlands is a major downward balancing energy provider, together with Norway and Belgium**. The Netherlands is a net exporter because it has little demand but has supply available for export.
- For upward RR:
  - In option 3, **flows are from Switzerland and GB to France, and Ireland to a lesser extent.** GB is a net exporter because it has little demand but has supply available for export. Switzerland is an exporter of upward balancing energy because it can export significant amounts of hydropower at a fairly low cost compared to thermal.
- For downward RR:
  - **In option 3, France is net importer of downward balancing energy, mainly coming from GB.** GB is a net exporter because it has little demand but has supply available for export.

France is mainly impacted by option 3 with a significant positive consumer surplus and a significant negative producer surplus

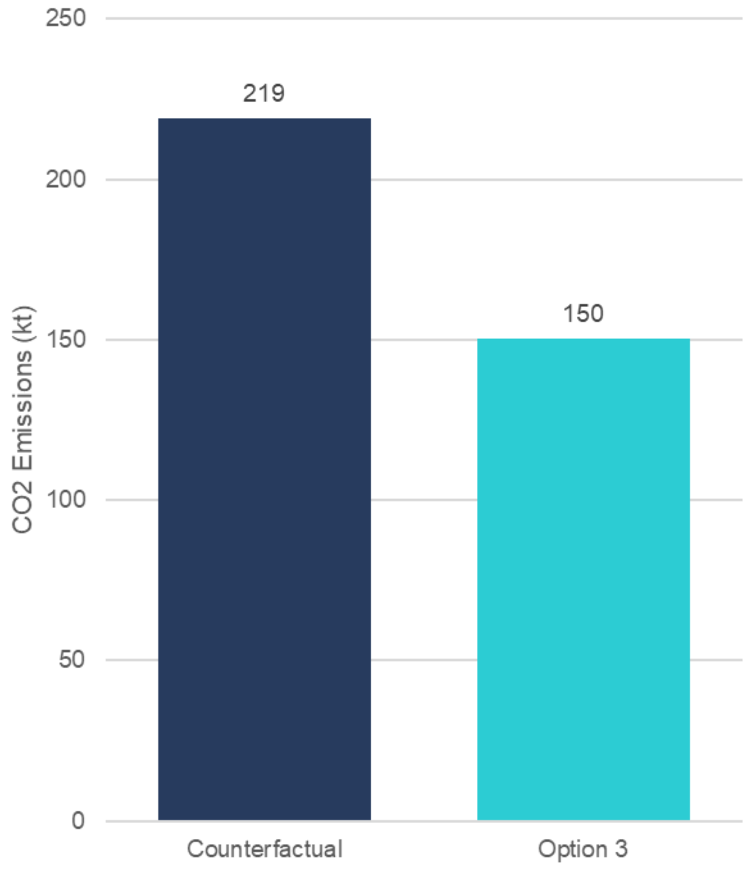
Variation of the consumer/producer/interconnector surplus Option 3 vs counterfactual



- For France, the sharing of bids and demands as defined in option 3 leads to a significant reduction in consumer costs in France thanks to imports of balancing energy at a better price, resulting in a significative positive consumer surplus but conversely a significative negative producer surplus. As a result, the decrease in the producer surplus is even higher in absolute terms than the increase in the consumer surplus, **resulting in a negative country benefit of -9M€.**
- There is also a significant reduction in consumer costs (positive consumer surplus) in GB, mainly through import balancing energy at a better price and therefore lower activation cost, **resulting in a country benefit of 7M€ for GB**
- Switzerland and the Netherlands export more balancing energy in option 3 than in the counterfactual, generating a positive producer surplus, **resulting in a positive country benefit** (6M€ and 8M€ respectively).

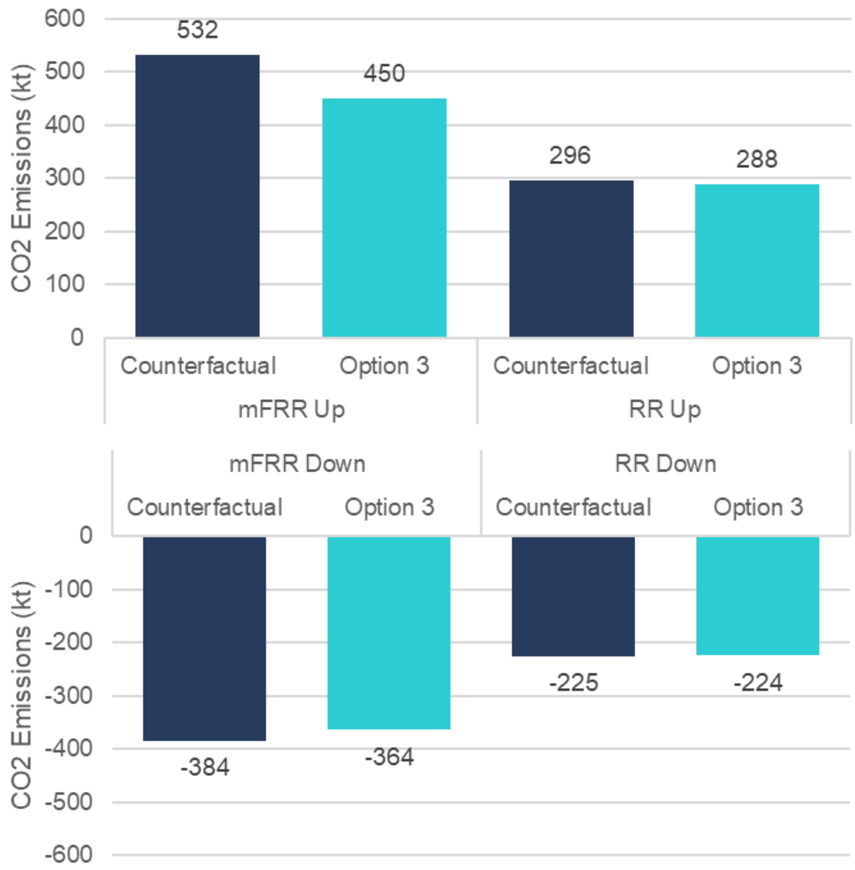
CO2 emissions are lower in option 3 than in the counterfactual, mainly due to lower CO2 emissions in upward mFRR

CO2 emissions – Option 3 – mFRR + RR - 2030



- **CO2 emissions are lower in option 3 than in the counterfactual,** mainly due to lower CO2 emissions in upward mFRR.
- In upward mFRR, supply and demand sharing in option 3 reduces the use of thermal power plants, mainly by replacing them with hydro, mainly French hydro exporting to GB, and Swiss hydro to the rest of Europe.
- In the other reserves (upward RR, downward mFRR and downward RR), the results are quite similar between the counterfactual and option 3.

CO2 emissions – Option 3 – Up and Down - 2030



Note: CO2 emissions for downward mFRR and RR are represented in negative because the downward activation corresponds to a decrease in production, thus a reduction in emissions for thermal power plants.

2.3

Modelling and Cost-Benefit Analysis of base case

3. Option 1 – UK CBB platform before TERRE/MARI

Option 1: Activation in the UK market before having to submit bids for TERRE/MARI

Indicative times						
for UK RR :	H – 64’	H – 60’	H – 55’	H – 40’	H – 36’	H – 30’
for UK mFRR :	H – 34’	H – 30’	H – 25’	H – 12’	H – 8’	H – 7.5’

Functioning: Bids retained in the UK market cannot participate in the TERRE/MARI platforms.

1. Submission of bids: Sequenced. Submission in the UK market sufficiently before the TERRE/MARI deadlines to allow the clearing and result phases.
2. Submission of needs: Sequenced. Submission from ESO could be achieved in parallel to BSP submission to gain time.
3. Clearing/activation: Sequenced. Clearing in the UK market should be finished before the BSPs submission in TERRE (H-55’) or MARI (H-25’) in order to allow the excluded bids to participate to TERRE/MARI.

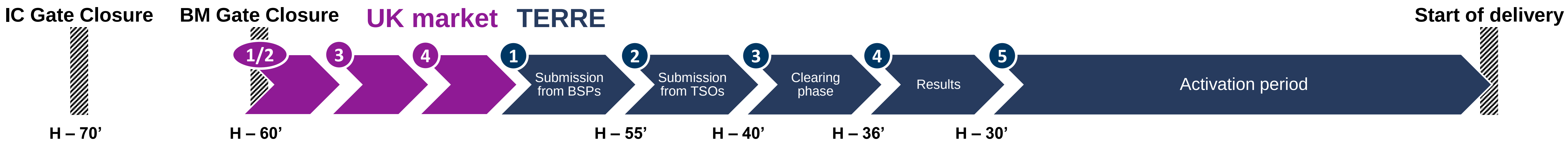
Key concerns

Could allow ‘slower’ products to participate in the UK market as the activation results would be known before the submission in TERRE/MARI.

In practice, the UK markets would be intermediate markets between ID, RR and mFRR.

- For the UK RR, there could be an interaction with the gate closure of the cross-zonal ID markets.
- For the UK mFRR, there could be an overlap with TERRE products as activation would happen at the same time.

Details on the timing constraints – option 1



Giving the existing deadlines for BM in the UK (H – 60’) and submission to TERRE (H – 55’), the process for a new market before TERRE is extremely constrained.

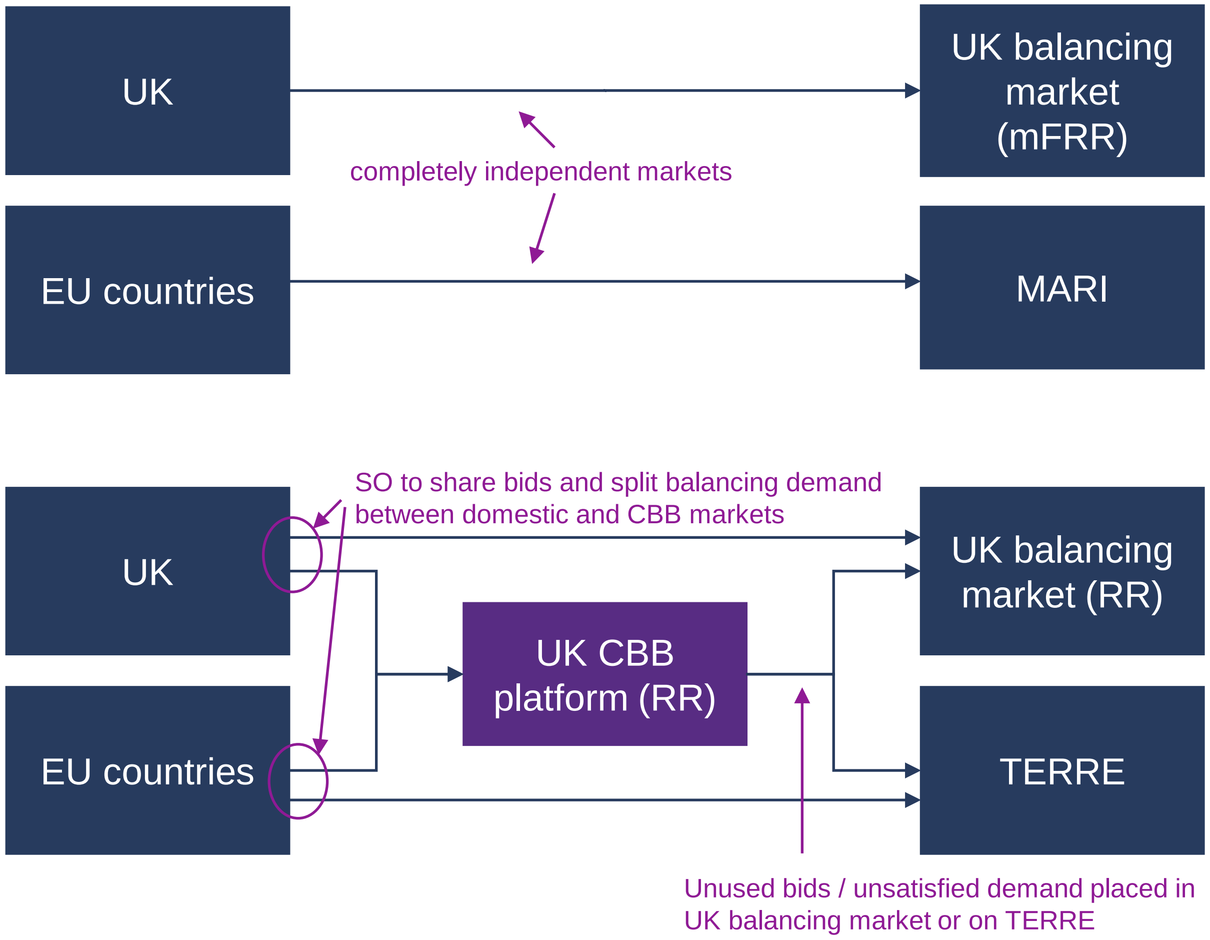
If the required time to run the new market is larger than 5 minutes, it would require:

- to shorten the TERRE timelines; and/or
- to push back BM Gate Closure.

If the required time to run the new market is 15 minutes, as indicated by NGESO, and the TERRE timelines are considered fixed, the condition for this option to be possible is:

Prerequisite for option 1:
Pushing back BM Gate Closure to H-70’ in line with the interconnector Gate Closure.

Option 1 – Cross-border balancing platform with UK before TERRE / MARI platforms



- **mFRR**:
- UK domestic market and MARI completely independent.

NB: Switzerland is modelled in a similar way to Great Britain: only domestic market (no participation in MARI).

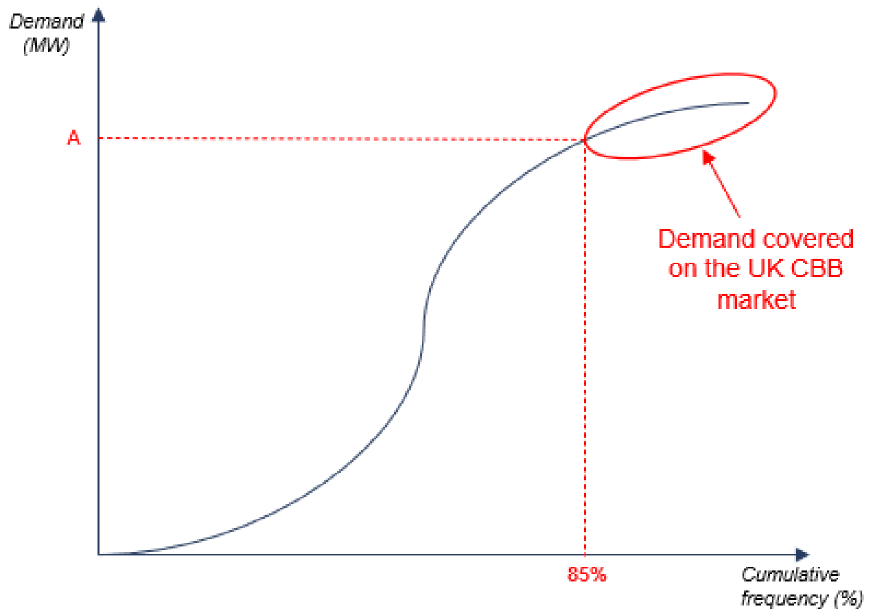
- **RR**:
- UK CBB platform: participation of UK and modelled countries with RR. Demand and supply of the different participants according to the principle stated in next slide. The existence of this platform ahead of TERRE allows the nuclear to be able to make offers on this market.
- UK domestic market: only UK with demand and supply not selected on the UK CBB market.
- TERRE: the other European countries modelled (excluding the UK and CH) with demand and supply not selected on the UK CBB market.

NB: Switzerland is modelled in a similar way to Great Britain: participation in the UK CBB platform and domestic market (no participation in TERRE).

Modelling the split of demand and supply between UK CBB platform and other platforms (UK domestic market, MARI or TERRE)

Demand

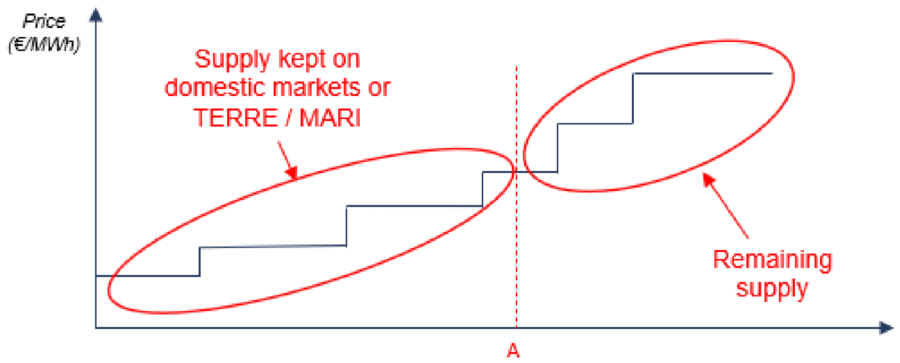
Cumulative demand over the year:



Note: All demand above A is placed on the UK CBB platform, we do not consider any optimisation or learning curve when using the platforms.

Supply

1. Countries keep the cheapest supply that allows them to cover its demand in 85% of the hours when there is activation.
   - This supply for the UK (and CH) would be placed on their domestic markets.
   - This supply for the other European countries would be placed on MARI or TERRE.
2. For the remaining supply:
   - The remaining supply on the UK (and CH) side would be fully placed on UK CBB market.*
   - The remaining supply on the other European countries would be split between the 2 CB markets (30% on UK CBB market and 70% in MARI or TERRE).*
   - **In addition, under option 1, all supply not accepted for RR for the other European countries are replaced on TERRE.**

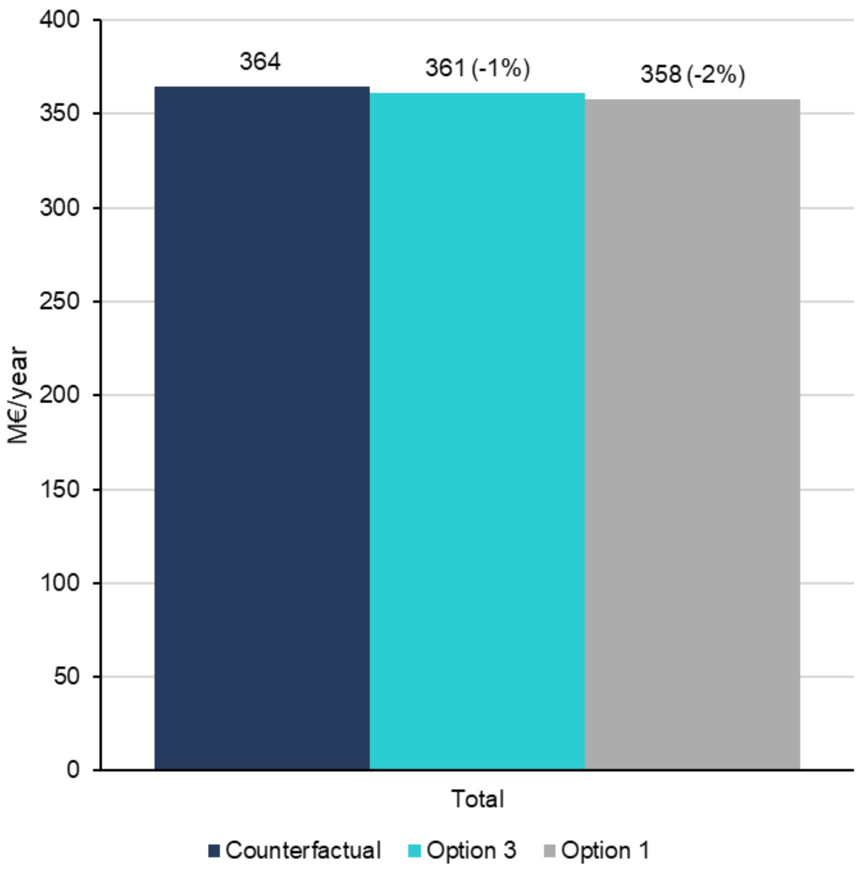


Note: At least all demand in the UK CBB platform must be offered in supply.

***: For RR Down, the existence of UK CBB platform ahead of TERRE allows the nuclear to be able to make offers on this market (but no nuclear supply in the domestic markets and TERRE).**

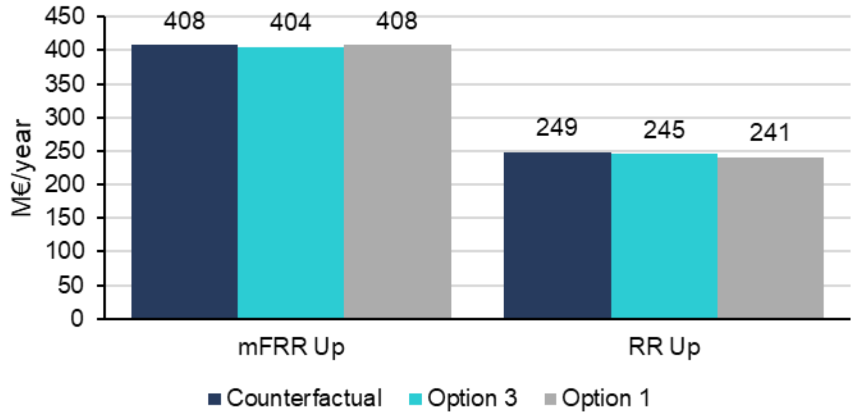
Having RR activation on the UK market in option 1 before having to submit bids for TERRE reduces slightly costs compared to a solution with parallel markets (option 3)

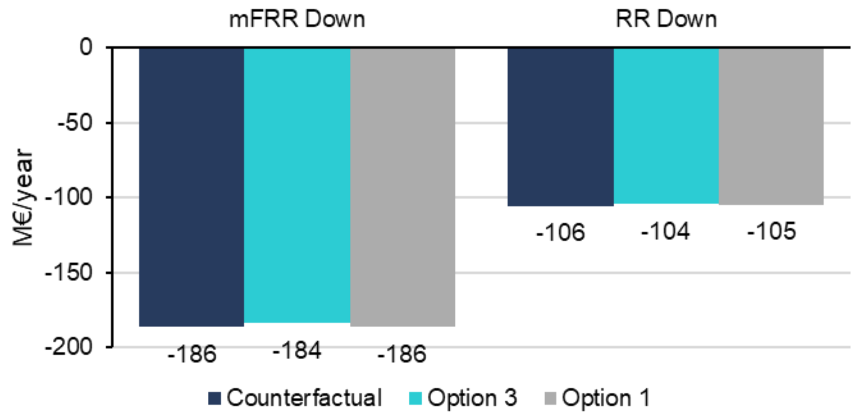
Activation cost – Option 1 – mFRR + RR - 2030



- **Option 1 reduces activation costs to a limited extent** but raises major implementation issues as it forces TSOs to anticipate gate closure, having significant impacts on markets and operational procedures.
- For upward RR, option 1 reduces costs because reintegrating the 30% of unused UK CBB bids into TERRE allows better use of supply.
- For downward RR, revenues increase slightly with the same reason as upward RR but also because it allows nuclear to offer RR Down activation. However, as nuclear offers a lower price (in absolute terms) than most thermal power plants, it is not activated very often.

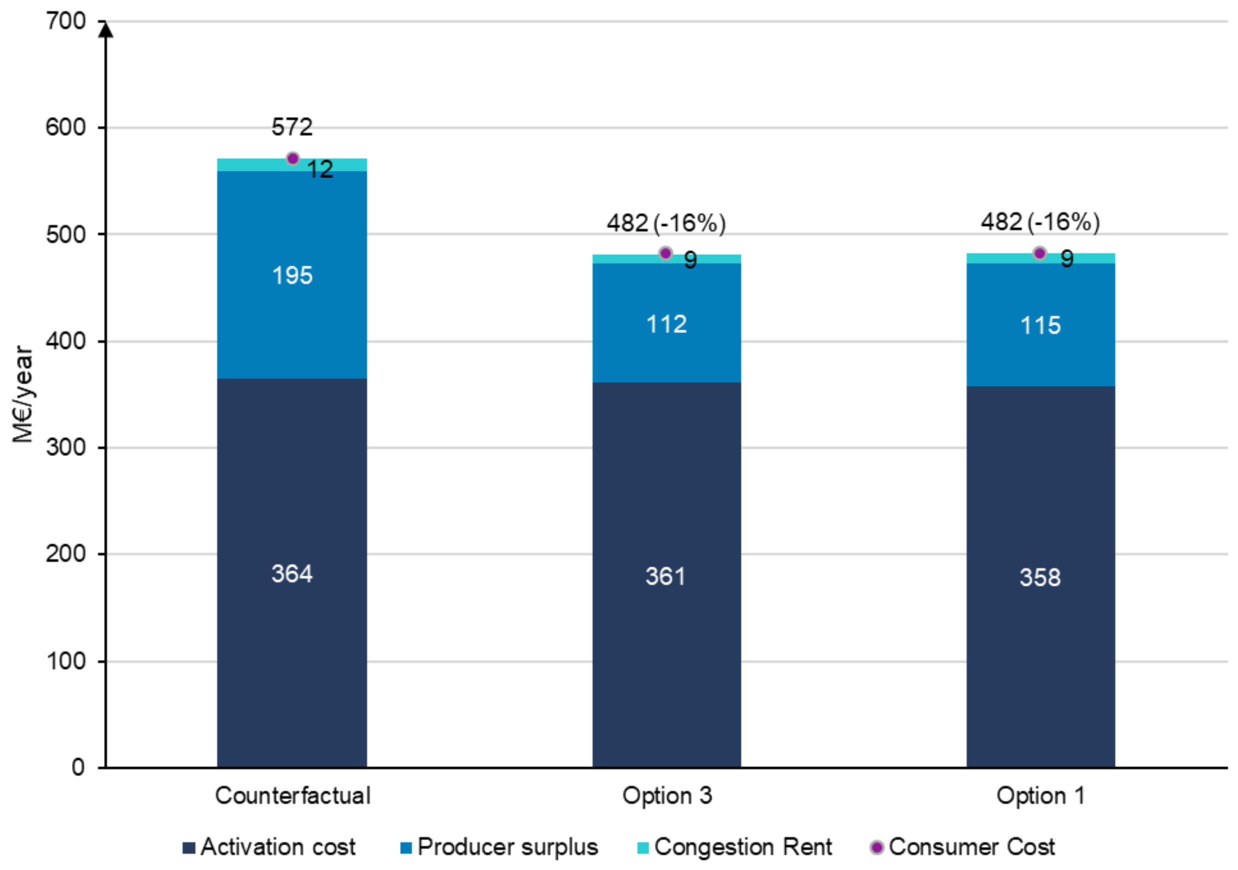
Activation cost – Option 1 – Up and Down - 2030





The demand breakdown in option 1 leads to a significant decrease in consumer costs compared to the counterfactual

Option 1 results for the different indicators - mFRR + RR - 2030



- Having RR activation on the UK market in option 1 before having to submit bids for TERRE also reduces the consumer cost compared to the counterfactual, in equivalent proportions to option 3 compared to the counterfactual.
- Indeed, the **reduction of demand in EU platforms** (and UK domestic markets) together with the sharing of the less expensive offers lead to a price reduction in the EU platforms, hence applied to large volume. This **reduction in prices in these platforms largely exceeds the similar or higher prices in the UK CBB platform**.
- This option raises major implementation questions as it forces TSOs to anticipate the gate closure, having significant impacts on markets and operational procedures.
- **The ability to reach such benefits in Option 1 can also be questioned**. Anticipating the gate closure of intraday markets could affect their efficiency and these negative impacts may outweigh the benefits of CBB. Moreover, TSOs will have to anticipate their balancing needs' estimations, with higher risks of getting it wrong. This could dampen the overall efficiency of balancing, which is not captured in the model.

In option 1, flows for RR are close to those of option 3

Net interchange of balancing energy (GWh)

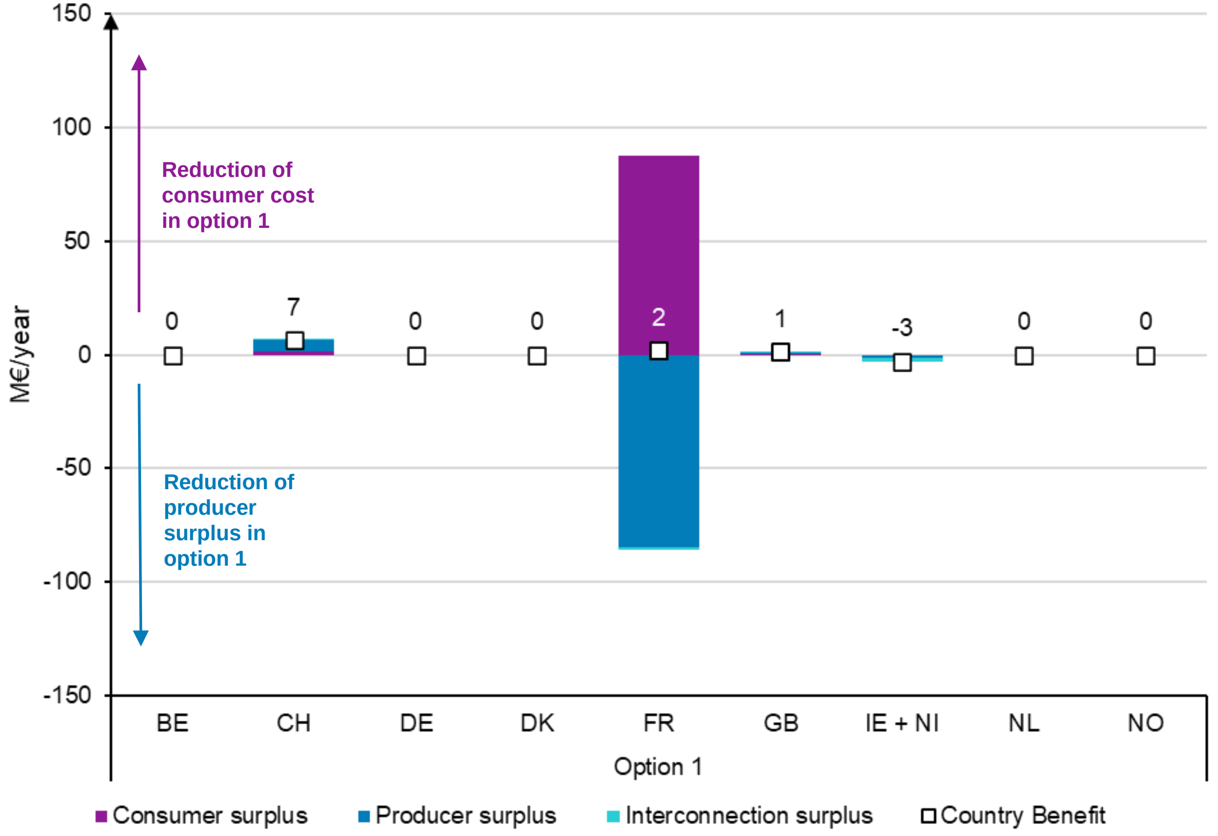
Net export (GWh)	mFRR		RR		Total
	Down	Up	Down	Up	
BE	160	-109	0	0	52
CH	0	0	9	129	139
DE	-222	-91	0	0	-313
DK	-13	149	0	0	136
FR	-267	-93	-121	-173	-653
GB	0	0	83	59	142
IE + NI	-5	-28	29	-16	-20
NL	318	10	0	0	327
NO	28	161	0	0	189

Up: Net interchange of upward balancing energy (>0: net exporter, <0: net importer)
Down : Net interchange of downward balancing energy. For downward energy, >0 means a net exporting position of downward energy, i.e. in practice the concerned country is importing energy.

- For upward mFRR:
  - **Results in upward mFRR are the same as in the counterfactual with no trade between Great Britain, Switzerland and the rest of Europe.** As a reminder, GB, Germany, France and Belgium are net importers of upward balancing energy while Norway and Denmark (and the Netherlands to a limited extent) are net exporters of upward balancing energy.
- For downward mFRR:
  - **Results in downward mFRR are the same as in the counterfactual with no trade between Great Britain, Switzerland and the rest of Europe.** As a reminder, Germany, France and Denmark are net importers of downward balancing energy while the Netherlands is a major balancing energy provider, together with Norway and Belgium.
- For upward RR:
  - In option 1, similarly to option 3, **flows are still from Switzerland and GB to France, and Ireland.** GB is a net exporter because it has little demand but has supply available for export. Switzerland is an exporter of upward balancing energy because it can export significant amounts of hydropower at a fairly low cost compared to thermal.
- For downward RR:
  - In option 1, similarly to option 3, **France is still net importer of downward balancing energy, mainly coming from GB.** GB is a net exporter because it has little demand but has supply available for export.

In option 1, importing balancing energy for France at a lower cost reduces the consumer cost but also reduces the producer surplus

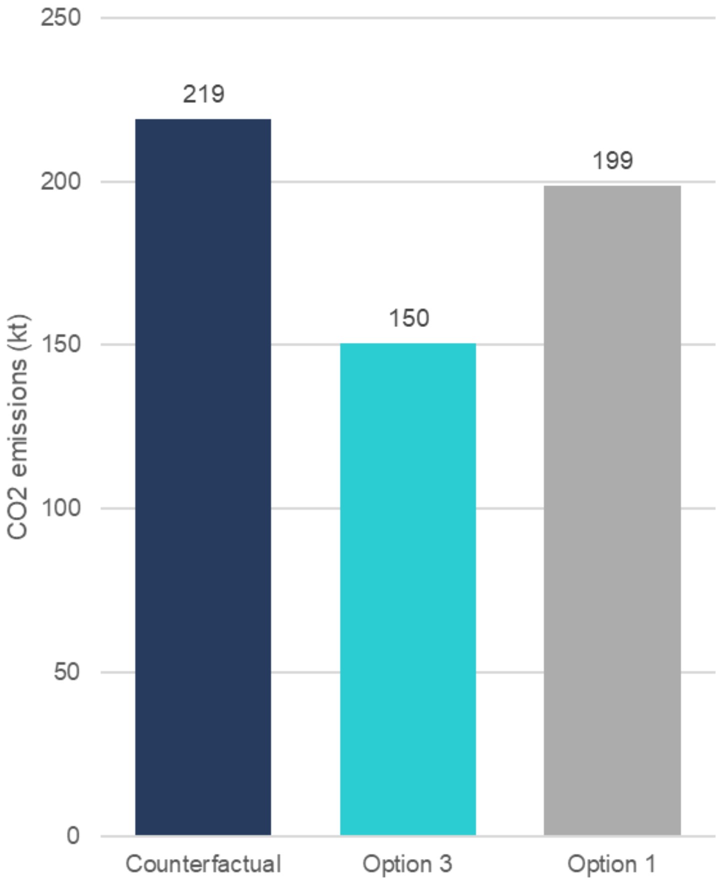
Variation of the consumer/producer/interconnector surplus
Option 1 vs counterfactual



- In option 1, **only the upward RR and the downward RR change relative to the counterfactual**, so option 1 brings changes relative to the counterfactual only in France, Great Britain, Ireland and Switzerland.
- **For France**, the sharing of bids and demands as defined in option 1 leads to a significant reduction in consumer costs in France thanks to imports of balancing energy from Great Britain and Switzerland at a better price, resulting in a **significative positive consumer surplus (reduced consumer cost) but conversely a significative negative producer surplus**. As there are only two modelled countries on TERRE, allowing exchanges with two additional countries results in a significant impact. In the end, the consumer surplus and the producer surplus almost totally offset each other with **a country benefit of 2M€ for France.**
- Switzerland exports more balancing energy in option 1 than in the counterfactual, generating a positive producer surplus, **resulting in a positive country benefit of 7**M€.
- Even if Great Britain exports quite a lot of balancing energy to France, **it does not have a very large producer surplus**, in the end only 1M€.

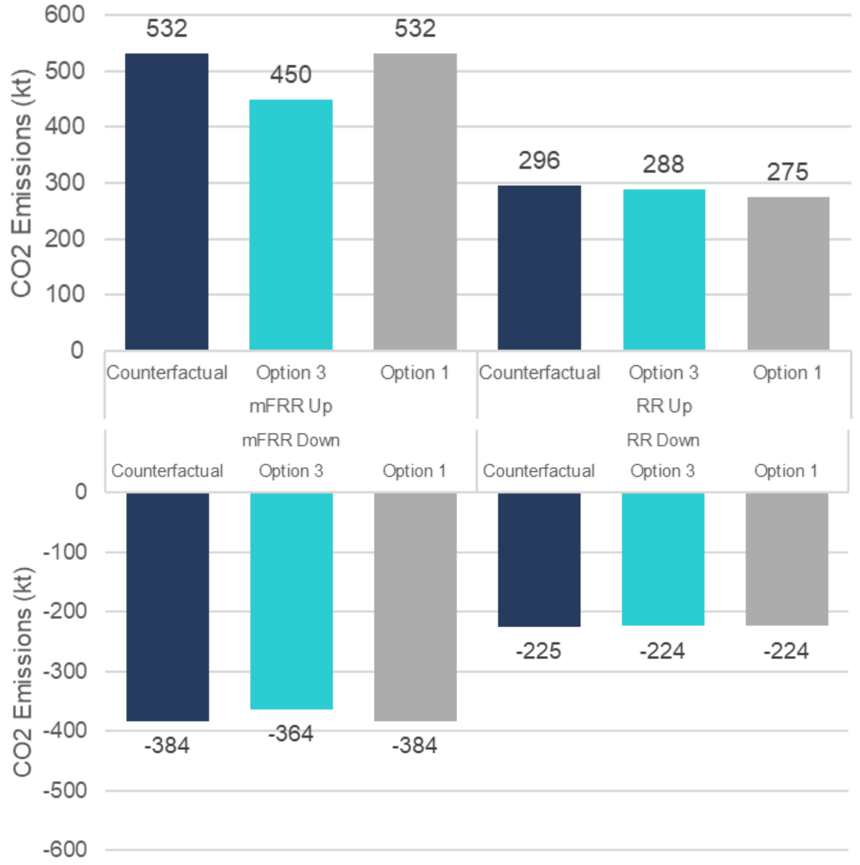
CO2 emissions are slightly lower in option 1 than in the counterfactual, mainly due to lower CO2 emissions in upward RR

CO2 emissions – Option 1 – mFRR + RR - 2030



- **CO2 emissions are slightly lower in option 1 than in the counterfactual,** mainly due to lower CO2 emissions in upward RR.
- In upward RR, supply and demand sharing in option 1 reduces CO2 emissions, with the reintegration of the 30% of unused UK CBB bids into TERRE allows better use of supply.
- In downward RR, results are quite similar between the counterfactual and option 1.
- Results in upward mFRR and downward mFRR are the same as in the counterfactual with no trade between Great Britain, Switzerland and the rest of Europe

CO2 emissions – Option 1 – Up and Down - 2030



Note: CO2 emissions for downward mFRR and RR are represented in negative because the downward activation corresponds to a decrease in production, thus a reduction in emissions for thermal power plants.

2.4

Modelling and Cost-Benefit Analysis of base case

4. Option 5 – SOs directly nominate IC

Option 5: TSO directly nominate IC with the agreement of connected TSO

Functioning: TSO bilaterally exchange balancing services

1. Submission of bids: As of today. BSPs submit their bids on the local markets.
2. Submission of needs: Sequenced.
   - TSOs submit their needs mainly on their domestic platforms.
   - If they forecast a favourable cross-border opportunity, they may also share bids or request an activation to a connected TSO.
3. Clearing/activation: Sequenced.
   - Clearing of UK and EU platforms are done regardless of the other exchanges (as of today).
   - If the TSO-TSO request is accepted, the TSO can either wait for next auction to rebalance, either activate local resources (if legally/contractually possible).

Key concerns

TSOs should integrate IC availability and nominate IC capacity.

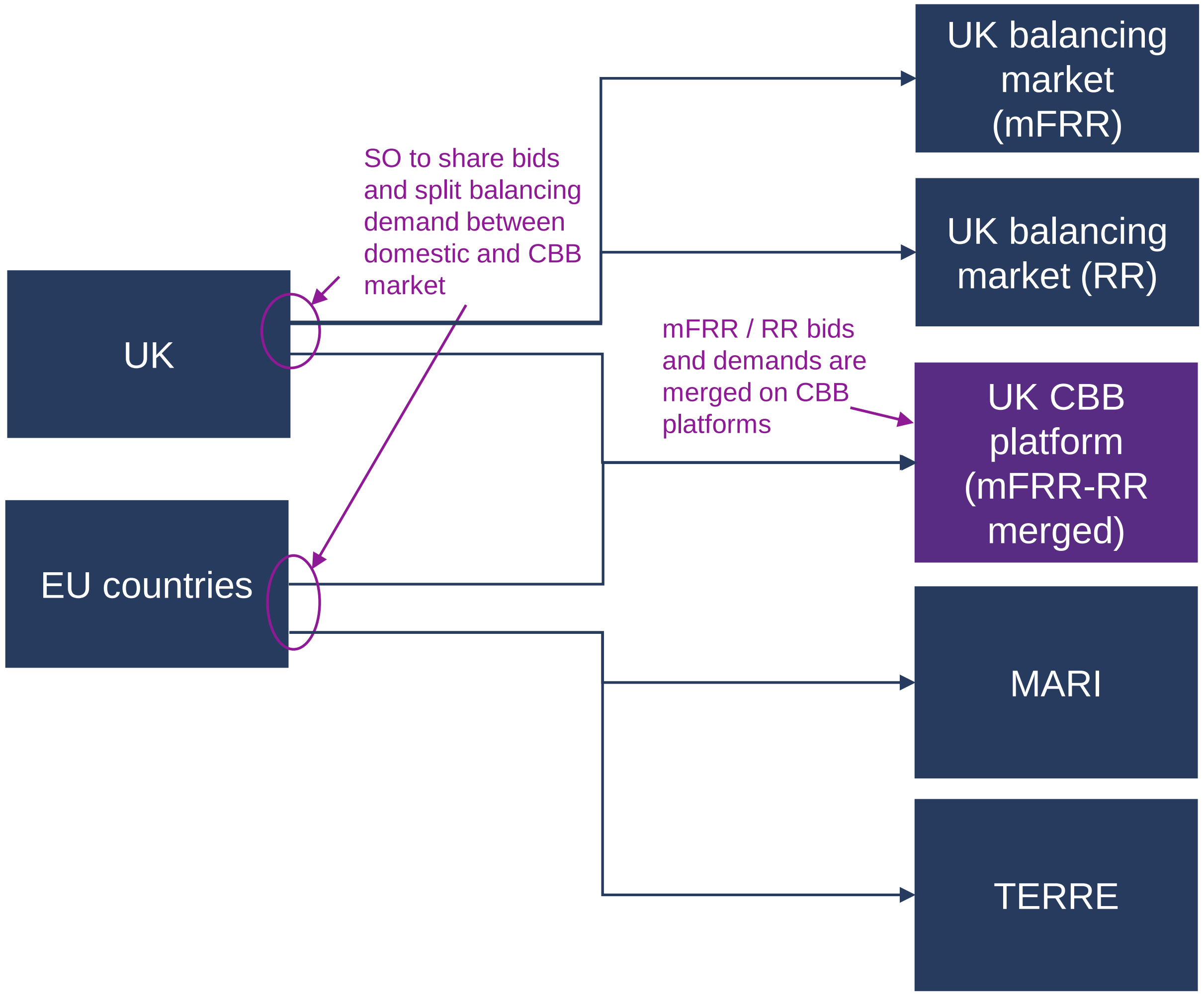
Products should be standardised to prevent overcomplexity.

TSOs should communicate their respective positions/ availabilities at different timeframes to allow the connected countries to request exchanges. Different possibilities:

- Continuous price for upward/downward activation;
- Fixed price on a given “window”.

To allow the activation of “intermediate” bids (e.g. 40’ activation time), there should be dedicated contracts between TSOs and BSPs for non-market activation.

Option 5 – SOs directly nominating IC capacity



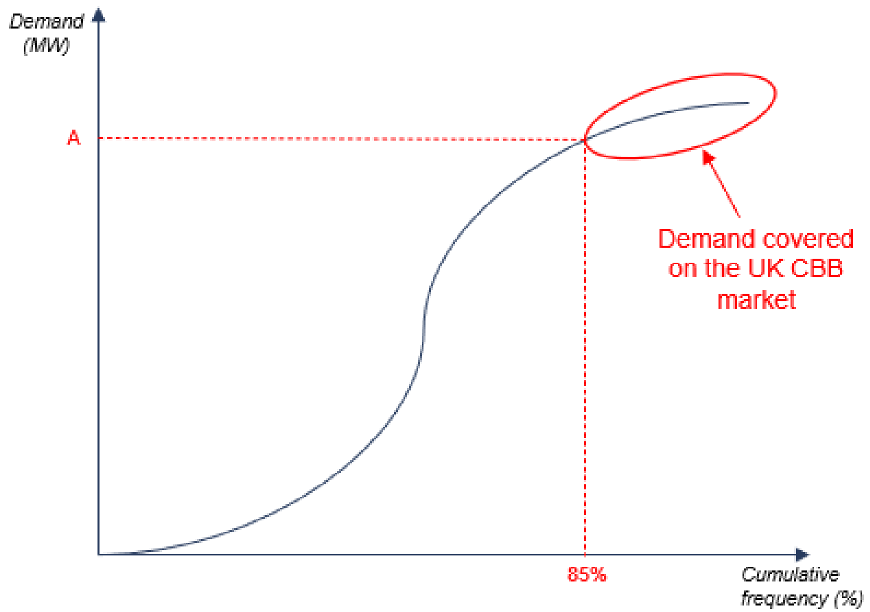
- **mFRR / RR**:
- UK CBB platform: participation of UK and other European modelled countries. Demand and supply of the different participants according to the principle stated in next slide. Data for mFRR and RR are merged.
- UK domestic market: only UK with demand and supply not placed on the UK CBB market.
- MARI-TERRE: the other European countries modelled (excluding the UK and CH) with demand and supply not placed on the UK CBB market.

NB: Switzerland is modelled in a similar way to Great Britain: participation in the UK CBB platform and domestic market (no participation in TERRE or MARI).

Modelling the split of demand and supply between UK CBB platform and other platforms (UK domestic market, MARI or TERRE)

Demand

Cumulative demand over the year:

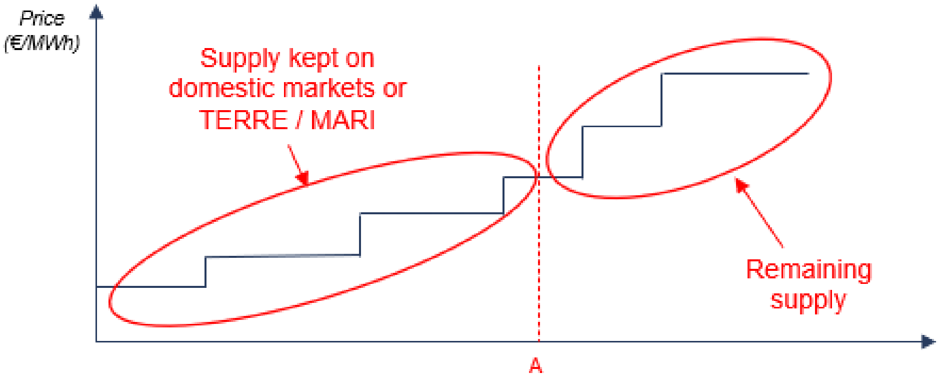


Under option 5, UK CBB demands for RR and mFRR are merged.

Note: All demand above A is placed on the UK CBB platform, we do not consider any optimisation or learning curve when using the platforms.

Supply

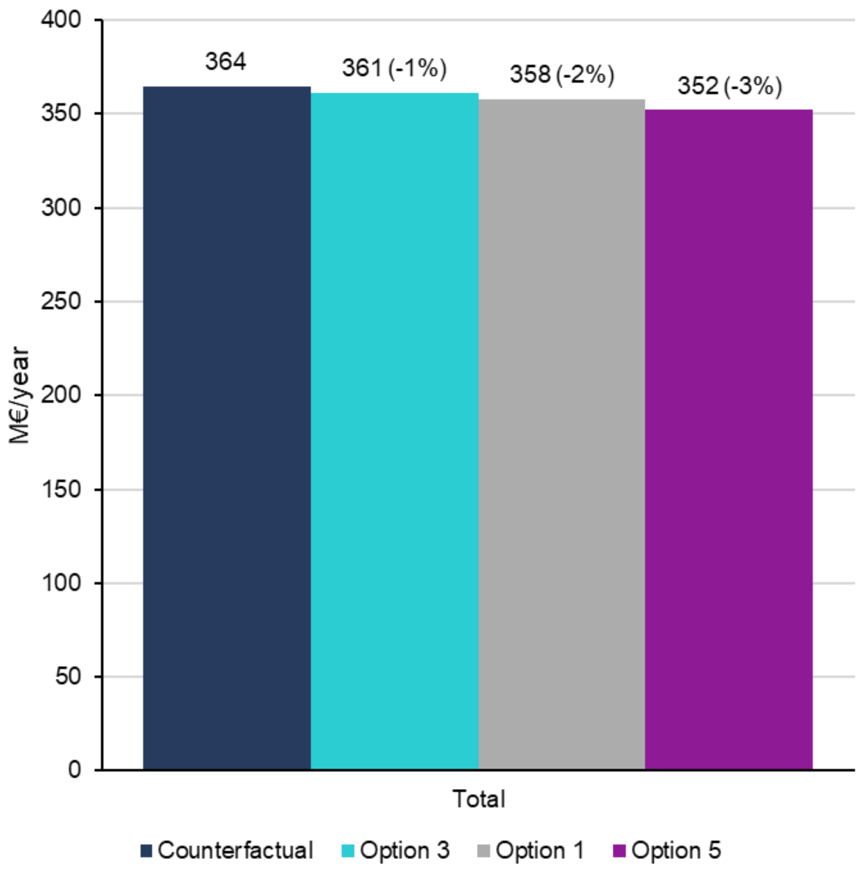
1. Countries keep the cheapest supply that allows them to cover its demand in 85% of the hours when there is activation.
   - This supply for the UK (and CH) would be placed on their domestic markets.
   - This supply for the other European countries would be placed on MARI or TERRE.
2. For the remaining supply:
   - The remaining supply on the UK (and CH) side would be fully placed on UK CBB market
   - The remaining supply on the other European countries would be split between the 2 CB markets (30% on UK CBB market and 70% in MARI or TERRE)
   - **In addition, under option 5, UK CBB supply for RR and mFRR are merged**.



Note: At least all demand in the UK CBB platform must be offered in supply.

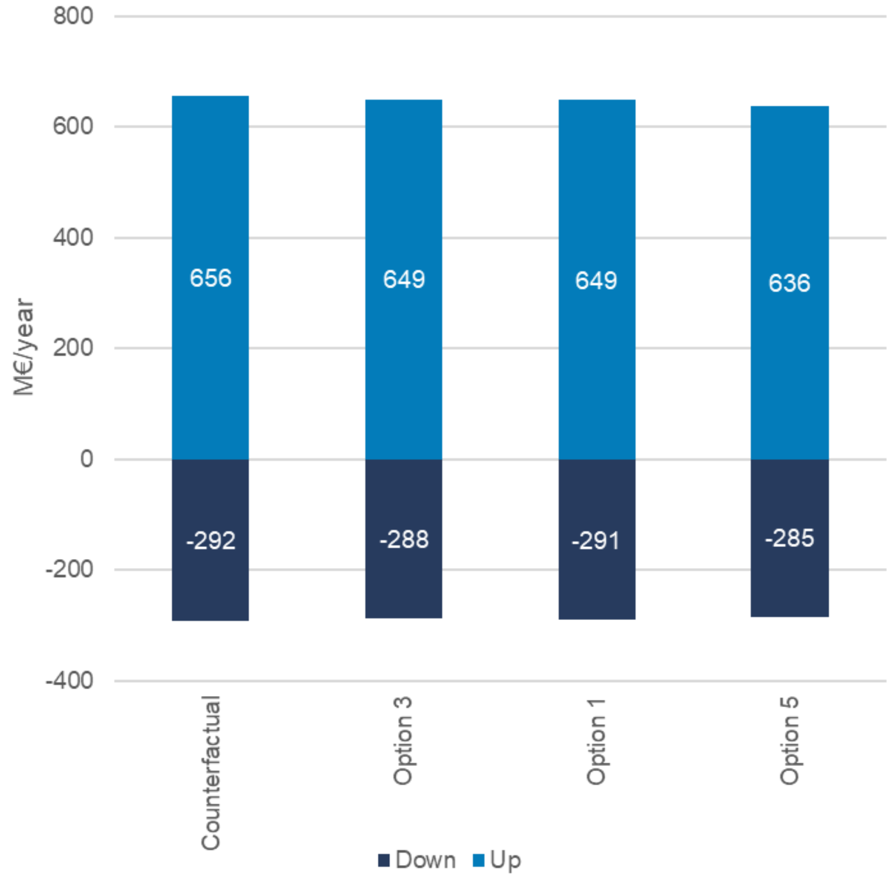
In option 5, sharing mFRR and RR bids on the UK CBB platform reduce costs compared to counterfactual and other options

Activation cost – Option 5 – mFRR + RR - 2030



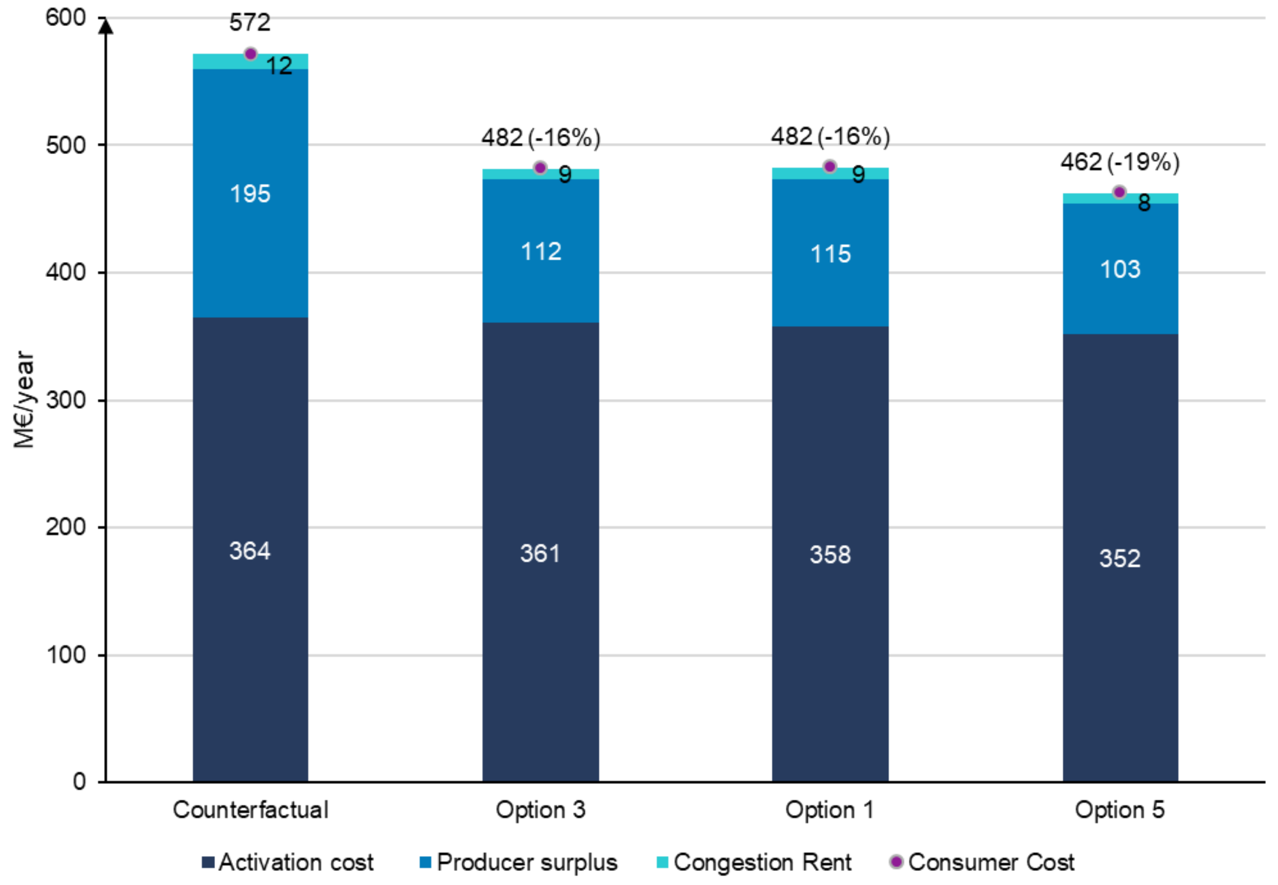
- **Option 5 allows mFRR and RR bids to be merged on UK CBB platform**, which often allows cheaper power plants to be activated, especially in upward mFRR/RR, **resulting in a lower activation cost.**
- However, this option also sometimes leads to an increase in demand (when there is a stack of mFRR and RR demand) which necessitates seeking more expensive supply (or less expensive for downward mFRR/RR) to meet the demand and thus increasing activation costs. This is particularly true in downward mFRR/RR, explaining why downward revenues from this option are lower than those of the other options.

Activation cost – Option 5 – Up and Down - 2030



The mutualisation of the mFRR and RR on the UK CBB platform reduces the consumer cost compared to the counterfactual and other options

Option 5 results for the different indicators- mFRR + RR - 2030



- **Option 5lead to a significant reduction** of consumer costs, because of **the rules for allocating demand between UK CBB and TERRE / MARI platforms and to price formation.**
- Indeed, the **reduction of demand in EU platforms** (and UK domestic markets) together with the sharing of the less expensive offers lead to a price reduction in the EU platforms, hence applied to large volume. This **reduction in prices in these platforms largely exceeds the similar or slightly higher prices in the UK CBB platform**.
- In addition, **TSOs may also adapt the post-processing of the selection of the bids and their pricing**, that may impact the split of costs and benefits between producers and consumers.
- **Option 5 seems to offer the greatest reduction in consumer costs**, but subject to the same limitations in the technical possibility of merging merit orders of two different products.
- Indeed, **the benefits of this approach are likely overestimated – all other things being equal – due to the modelling approach as it combines two products that have different characteristics** in particular as regards activation times (from 12.5min in mFRR to 30min in RR). Therefore, in practice, TSOs would unlikely be technically able to fully merge the merit orders.

In option 5, flows are quite similar to those of the other options

Net interchange of balancing energy (GWh)

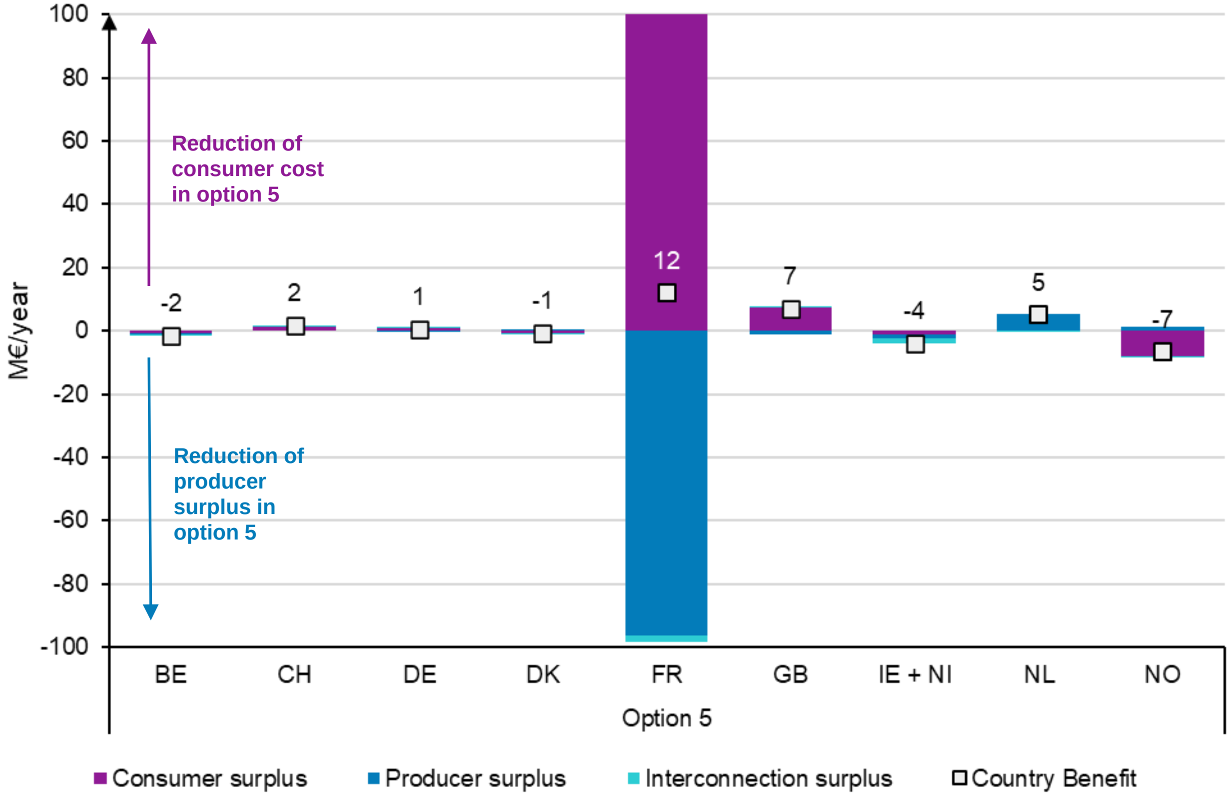
Net export (GWh)	Down	Up	Total
BE	132	-134	-2
CH	51	114	165
DE	-217	-115	-331
DK	-7	130	123
FR	-287	-227	-515
GB	95	-41	54
IE + NI	-4	-51	-55
NL	276	5	280
NO	-39	320	281

Up: Net interchange of upward balancing energy
Down : Net interchange of downward balancing energy
(>0: net exporter, <0: net importer)

- For upward mFRR/RR:
  - **GB, Germany, France and Belgium are net importers of upward balancing energy.** France is a major importer because of its large demand and Germany is a major importer because the price bids offer by its supply are high. In other options, GB is net importer of upward mFRR and a net exporter of upward RR to a lesser extent so by merging upward mFRR and upward RR, GB remains a net importer in low proportions in this option 5.
  - **Norway is a major provider of upward balancing energy, together with Denmark and Switzerland to a lesser extent.** Norway exports a lot of balancing energy to GB, but GB is also as a transit country for Norway to export more balancing energy to the rest of Europe.
- For downward mFRR/RR:
  - **Germany and France are net importers of downward balancing energy**. France is major importer of downward balancing energy because of its large demand.
  - **The Netherlands is a major balancing energy provider, together with GB and Belgium**. The Netherlands is a net exporter because it has little demand but has supply available for export. In other options, GB is net importer of downward balancing mFRR and a net exporter of downward balancing RR. In the end, by merging downward mFRR and downward RR, GB becomes a net exporter in this option 5.

In option 5, France and the UK have a significant positive country benefit while Norway has a negative country benefit

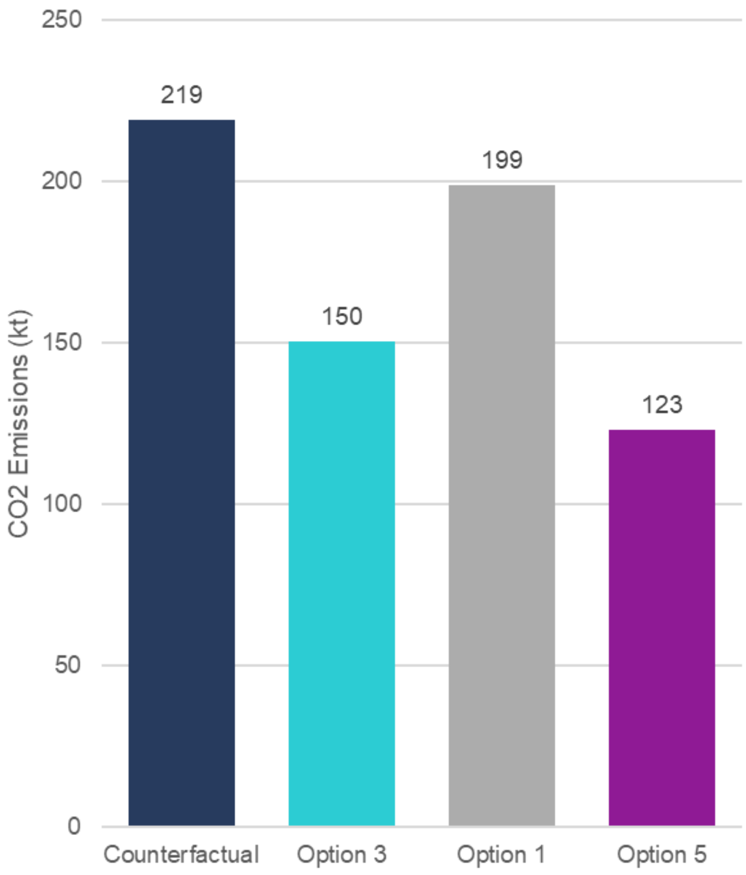
Variation of the consumer/producer/interconnector surplus Option 5 vs counterfactual



- For France, the sharing of bids and demands as defined in option 5leads to a significant reduction in consumer costs in France thanks to imports of balancing energy at a better price, resulting in a significative positive consumer surplus but conversely a significative negative producer surplus. In the case of option 5, the consumer surplus exceeds the producer surplus in absolute value, **resulting in a positive country benefit of around 12M€ in France.**
- There is also a significant reduction in consumer costs (positive consumer surplus) in GB, mainly through import balancing energy at a better price and therefore lower activation cost, **resulting in a country benefit of 7M€ for GB.**
- The Netherlands export more balancing energy in option 5 than in the counterfactual, generating a positive product surplus, **resulting in a positive country benefit** of 5M€.
- Norway exports more balancing energy in option 5 than in the counterfactual, leading to a price increase in Norway, resulting in a negative consumer surplus and a **negative country benefit of -7M€.**

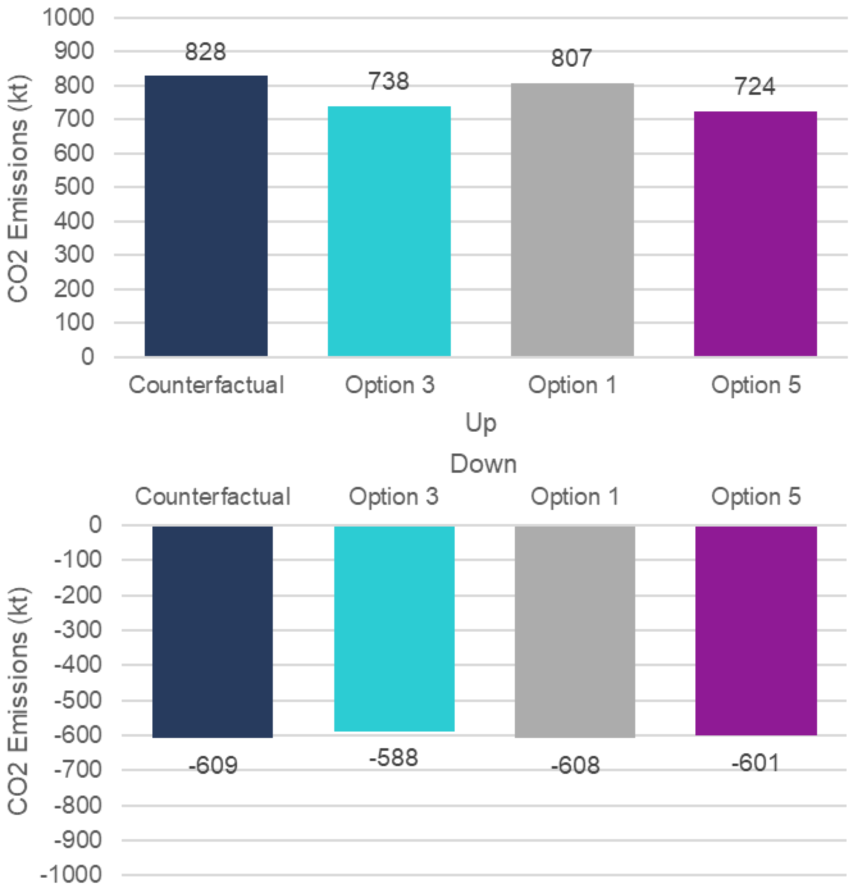
CO2 emissions are lower in option 5 than in the counterfactual and other options

CO2 emissions – Option 5 – mFRR + RR - 2030



- **CO2 emissions are lower in option 5 than in the counterfactual and other options,** mainly due to lower CO2 emissions in upward mFRR/RR.
- In upward mFRR/RR, merging mFRR and RR supply on UK CBB platform, allows more low-CO2 emitting capacity to be activated, for example by increasing the hydro capacity that is offered and then selected.
- In downward mFRR/RR, results are quite similar between the counterfactual and option 1.

CO2 emissions – Option 5 – Up and Down - 2030



Note: CO2 emissions for downward reserves are represented in negative because the downward activation corresponds to a decrease in production, thus a reduction in emissions for thermal power plants.

2.5

Modelling and Cost-Benefit Analysis of base case

5. Extension to 2040

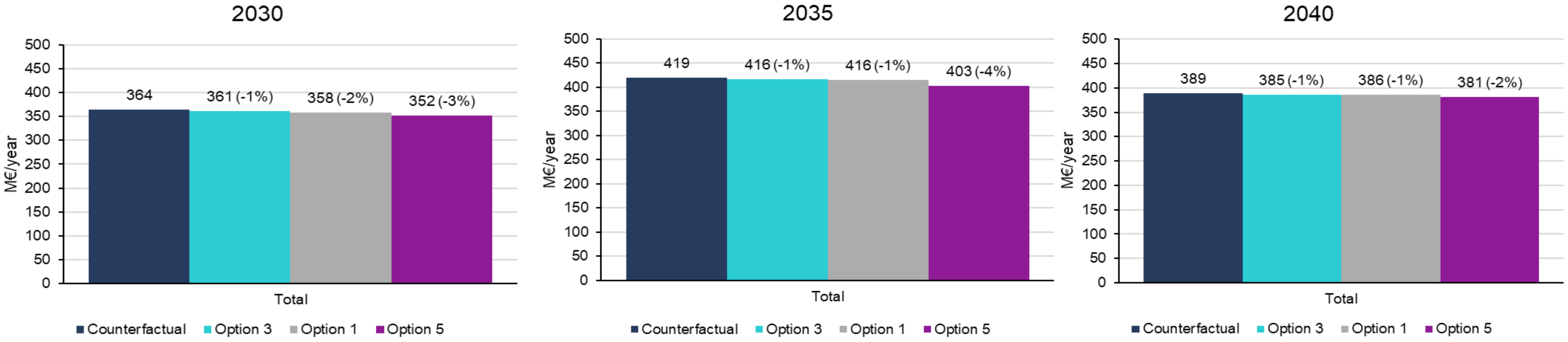
Results of the European power day-ahead (DA) market model from 2030 to 2040

Power prices in GB and interconnected countries (€/MW/h) – yearly average

Year	2030	2035	2040
Scenario	Base Case	Base Case	Base Case
GB	49.3	33.5	38.5
FR	69.9	59.0	60.0
DE	83.7	71.1	74.6
BE	74.3	66.8	68.6
NL	62.7	59.9	64.6
NO2	33.9	27.9	35.2
IE	53.6	50.8	67.4

Cross-border balancing options not based on the participation of GB in EU platforms have a limited impact on social welfare (limited cost reduction)

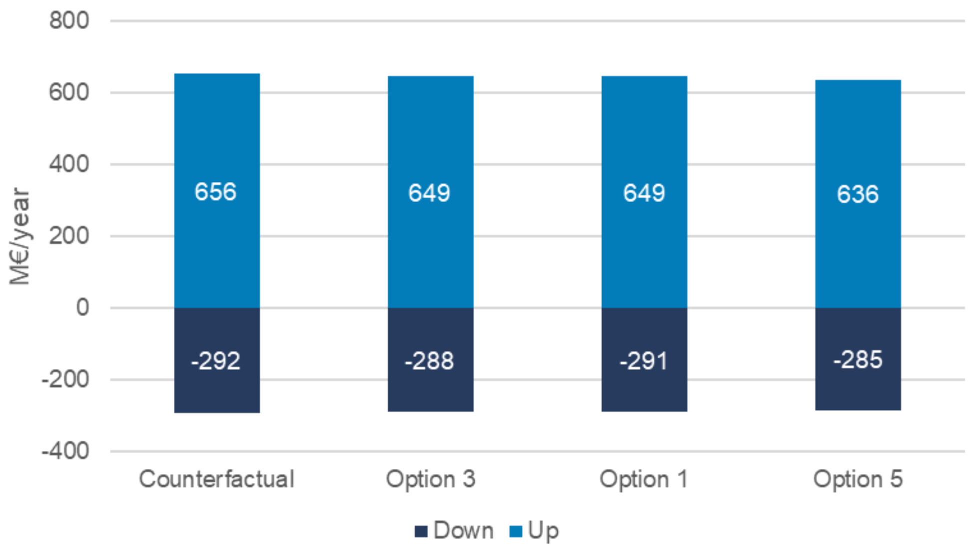
Activation cost – Different Options – Comparison 2030-2040 - Base Case



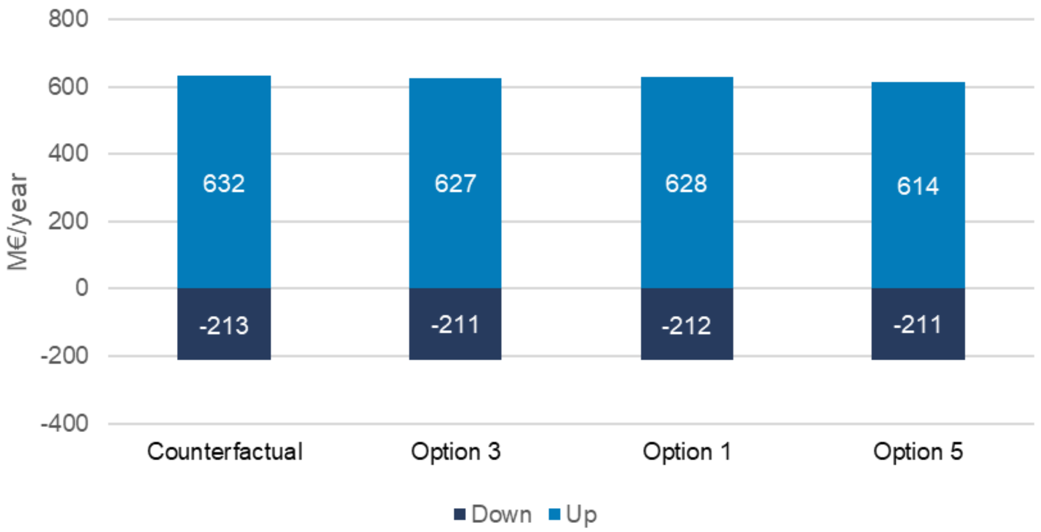
- From 2030 to 2040, the **activation costs are around 400M€** with an increase in activation costs in 2035 and a slight decrease in 2040 due to the share of thermal plants in the mix.
- The **total balancing costs in 2035 are higher than in 2030** because the revenues generated in downward mFRR and RR decrease while the costs of upward mFRR and RR remain quite stable – see next slide for more details.
- The total balancing costs in 2040 are higher than in 2035 because the **revenues generated in downward mFRR and RR** increase while the costs of **upward mFRR and RR remain quite stable. In 2040, more thermal generation** means **lower price in downward mFRR and RR (higher in absolute)** resulting in **higher revenues in downward mFRR and RR.** Thermal generation in 2040 increases with the evolution of the mix considered. Therefore, thermal plants are more in the merit on the power model and are willing to pay more often to buy back their electricity
- Cross-border balancing **options not based on the participation of GB in EU platforms do not lead to a significant reduction** of balancing activation costs, with a maximum 3% reduction in activation costs between the counterfactual and the options over the period.

In 2035, revenues generated in downward mFRR and RR decrease significantly and are only partially compensated by the decrease of activation costs in upward mFRR and RR

Activation Cost – Split between Up and Down – Base Case - 2030



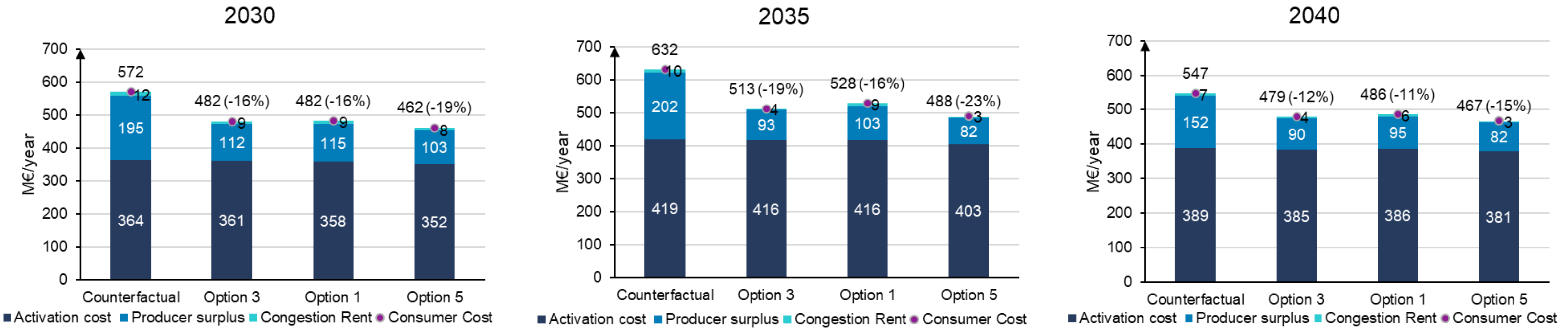
Activation Cost – Split between Up and Down – Base Case - 2035



- In 2035, **less thermal generation** means **higher price in downward mFRR and RR (lower in absolute)** resulting in **less revenues in downward mFRR and RR (about -25%)** because it is these thermal plants that make high price bids in downward mFRR and RR to buy back their electricity. This means at other times that technologies with a lower buyback prices are called.
- Compared to 2030, there is less thermal generation in 2035 with the closure of some power plants and lower prices limiting their frequency of use. However, it is these thermal plants that make high price bids in the downward mFRR and RR to buy back their electricity.
- In upward mFRR and RR, thermal power plants base their price bids on their SRMC. Hydro also bases its price bids on the SRMC of a standard CCGT and on power prices. However, **as the gas price is almost stable** (slightly decreasing) **and power prices decrease** on average **between 2030 and 2035**, the activation cost of **upward mFRR and RR slightly decreases between 2030 and 2035 (about -4%).**

Cross-border balancing options reduce consumer costs, mainly due to the breakdown of demand obtained through the platforms

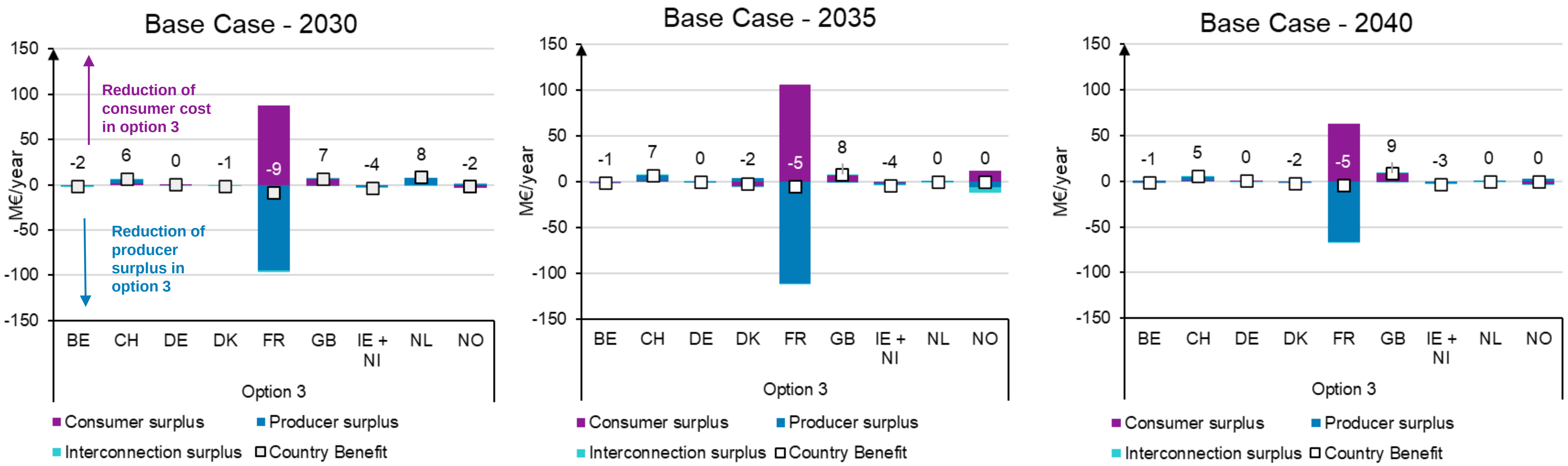
Consumer costs split – 2030-2040 – Base Case



- Similarly to **activation costs, consumer costs increase from 2030 to 2035 and decrease slightly from 2035 to 2040**.
- **Cross-border balancing options lead to a significant reduction** of consumer costs, because of **the rules for allocating demand between UK CBB and TERRE / MARI platforms and to price formation.**
- Indeed, the **reduction of demand in EU platforms** (and UK domestic markets) together with the sharing of the less expensive offers lead to a price reduction in the EU platforms, hence applied to large volume. This **reduction in prices in these platforms largely exceeds the similar or slightly higher prices in the UK CBB platform**.
- In addition, **TSOs may also adapt the post-processing of the selection of the bids and their pricing**, that may impact the split of costs and benefits between producers and consumers.
- **Option 5 seems to offer the greatest reduction in consumer costs**, but subject to the limitations in the technical possibility of merging merit orders of two different products.

Option 3 induces a positive country benefit for Great Britain and Switzerland from 2030 to 2040 compared to the counterfactual

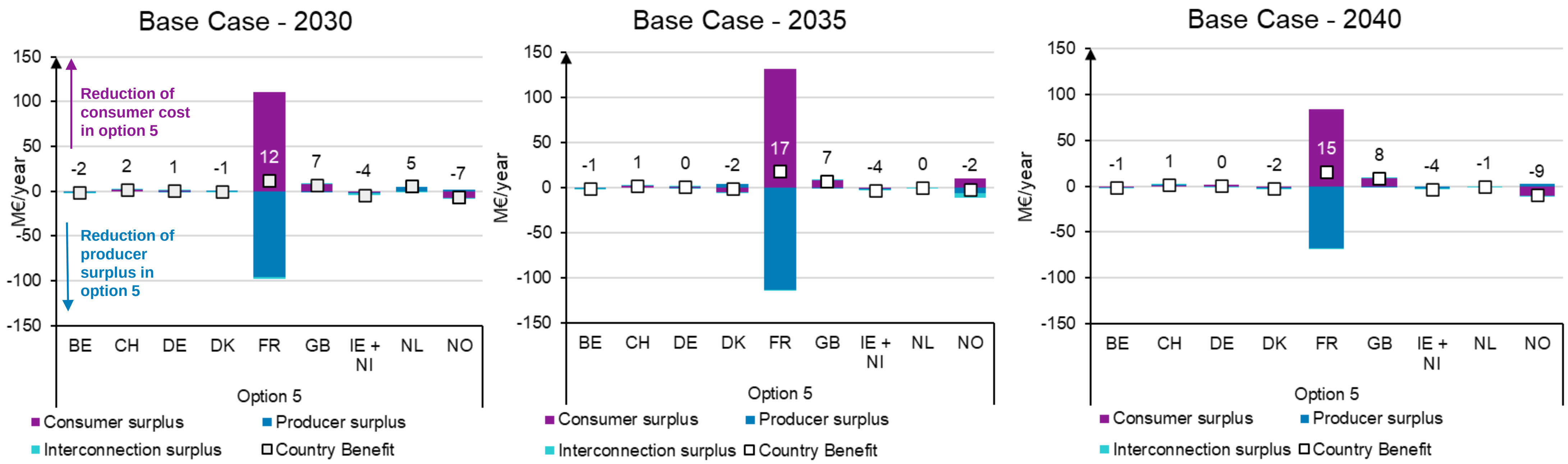
Country costs/benefits – Option 3 vs counterfactual



- In option 3, sharing bids between Great Britain, Switzerland and other European countries decrease the French consumer cost (positive consumer surplus) but decrease the surplus for French producers, **resulting however in a country benefit for France from -9M€ to -5M€**.
- The **country benefit for Great Britain remains quite stable from 2030 to 2040, positive by 7M€ to 9M€,** mainly due to the consumer surplus related to lower activation costs.
- Similarly for Switzerland, the country benefit **remains quite stable from 2030 to 2040** with a reduction in consumer costs and a positive producer surplus.

Option 5 induces a positive country benefit for France and Great Britain from 2030 to 2040 compared to the counterfactual

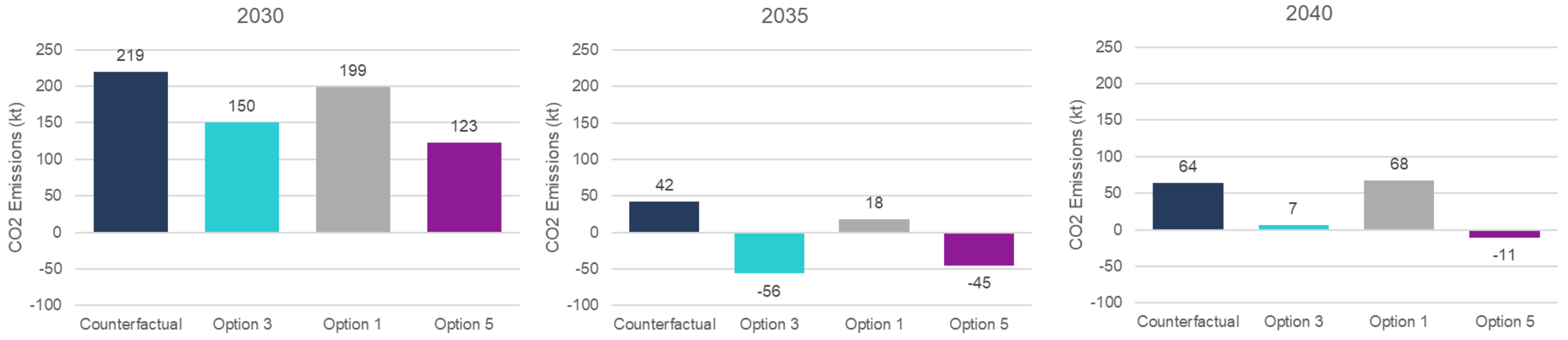
Country costs/benefits – Option 5 vs counterfactual



- In option 5, sharing bids between Great Britain, Switzerland and other European countries and merging UK CBB demands and supply for RR and mFRR decrease the French consumer cost (positive consumer surplus) but decrease the surplus for French producers, **resulting in a positive country benefit for France from 12M€ to 17M€**.
- The **country benefit for Great Britain remains quite stable from 2030 to 2040, positive by 7M€ to 8M€,** mainly due to the consumer surplus related to lower activation costs.

Options 3 and 5 allow for a reduction in CO2 emissions, albeit quite moderate when compared to the emissions of the overall power system

CO2 emissions – Different Options – Comparison 2030-2040 - Base Case



- From 2030 to 2040, emissions from mFRR / RR activation decrease with less thermal used for upward mFRR and upward RR activation but with still a lot of thermal used for downward mFRR and downward RR activation. **Negative values sometimes occur because the reduction in CO2 emissions allowed in downward reserves exceeds CO2 emissions in upward reserves.**
- Overall, **options 3 and 5 allow a reduction in emissions compared to the counterfactual** by allowing more decarbonised supply to be shared in upward mFRR and upward RR and more thermal supply to be shared in downward mFRR and downward RR.
- However, **CO2 emissions levels avoided by these options remain quite low when compared to the overall emissions of the power system, of the order of 200Mt in 2030 in our power dispatch model.**
- **Option 1 compared to the counterfactual allows for a slight reduction in CO2 emissions in 2030 and 2035, and even a slight increase in emissions in 2040**. Indeed, in the downward RR of option 1, the activation of nuclear partially replaces the activation of thermal power plants.

Note: CO2 emissions for downward reserves are represented in negative because the downward activation corresponds to a decrease in production, thus a reduction in emissions for thermal power plants.

3.

Modelling and Cost-Benefit Analysis of sensitivities

3.1

Modelling and Cost-Benefit Analysis of sensitivities

1. Sensitivity 1 – swapping Hydrogen out for Electrification of heating (GB)

List of sensitivities to assess the uncertainties in these markets

1 Swapping Hydrogen out for Electrification of heating (GB)	▪ We use the scenarios for heating and hydrogen from Consumer Transformation (FES 2022) as a sensitivity 1 instead of System Transformation (FES 2022) in the Base Case.
2 UK interconnection capacity of 25GW from 2030	▪ We use an UK interconnection capacity of 25GW in 2030 instead of 13GW in the base case.
3 High gas prices in the long term	▪ Due to a gas shortage in Europe because of the war in Ukraine, gas prices will remain high in the long term (i.e. 75€/MWh in 2030 instead of 25€/MWh in the base case), with gas imports remaining low and relying mainly on LNG imports.
4 More renewables in European countries	▪ We consider more renewables in European countries more offshore wind in Norway, more offshore wind in Sweden, more onshore wind and solar in Germany.
5 Increased involvement of new technologies	▪ We consider the involvement of new technologies to be twice as high in terms of proposed volumes as in the base case.
6 Share of balancing bids between domestic and cross-border platforms	▪ We consider a different share of balancing bids between domestic and cross-border platforms, placing 10% of bids on the UK CBB platform (rather than 30% in the base case) to represent a very constrained transmission network.

Sensitivity 1 – Description of the sensitivity

Description of the sensitivity:

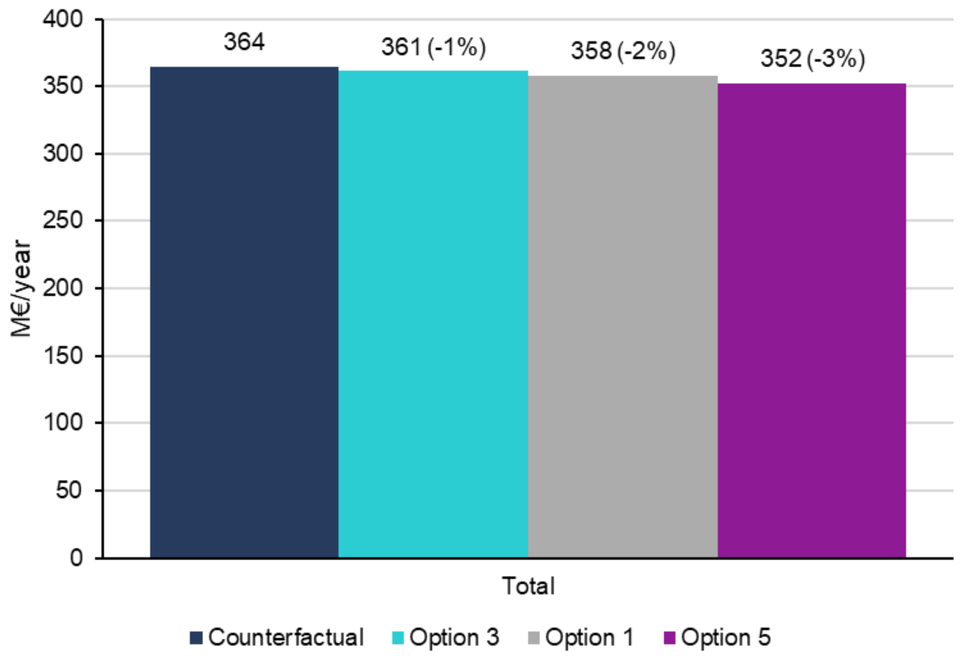
- We consider a higher electrification of heating than in the base case (from 16 to 28 TWh) but a lower production of hydrogen by electrolysis (from 12 to 4 TWh). We use the values from the Consumer Transformation scenario (FES 22) instead of the System Transformation scenario (FES 22) in the base case.

		2030
System Transformation (Base Case)	Heating (GWh)	16,217
Consumer Transformation (Sensitivity 1)		27,796
System Transformation (Base Case)	Demand for Electrolysis (GWh)	12,183
Consumer Transformation (Sensitivity 1)		3,865

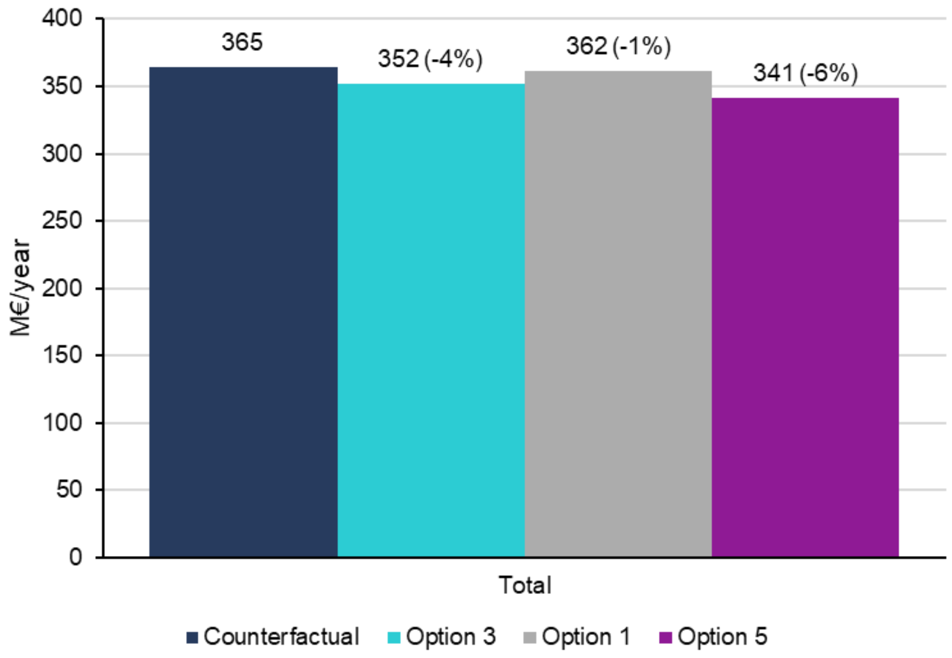
Year	2030	
Scenario	Base Case	Sensitivity 1
GB	49.3	53.0
FR	69.9	70.3
DE	83.7	83.9
BE	74.3	74.6
NL	62.7	62.9
NO2	33.9	33.2
IE	53.6	54.3

Overall, activation costs for sensitivity 1 are close to those of the base case

Activation cost – Base Case - 2030



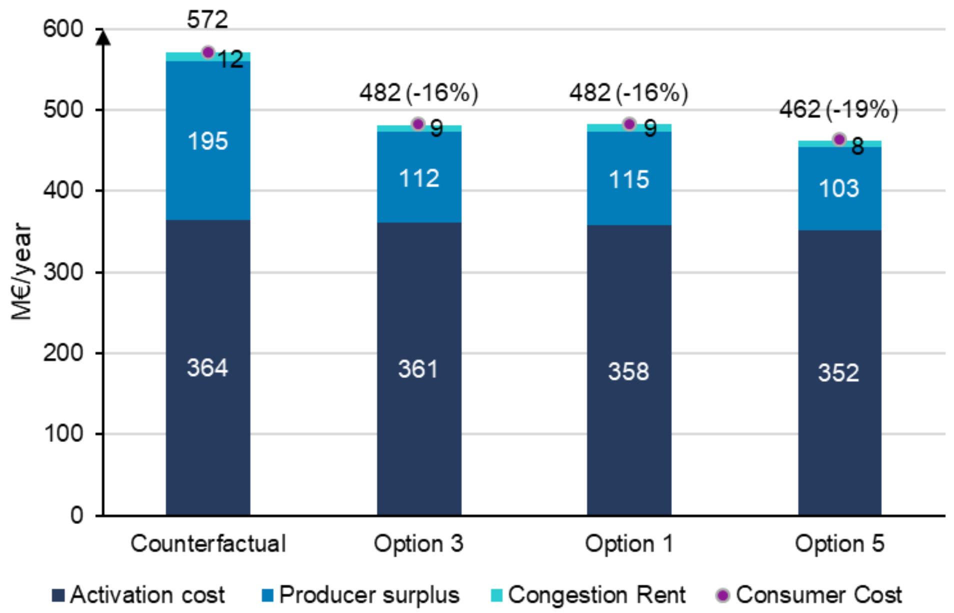
Activation cost – sensitivity 1 - 2030



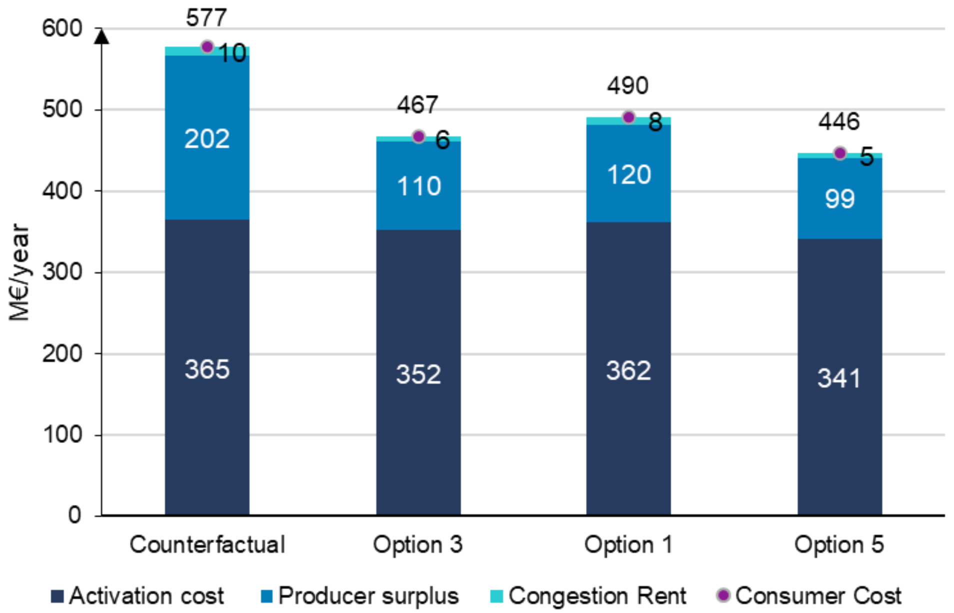
- **Overall, the activation costs of sensitivity 1 are very close to those of the base case.**
- However, we note a slight increase in activation costs in the counterfactual and option 1 and a slight decrease in options 3 and 5.
- In options 3 and 5, more optimised exports of balancing energy from the UK to France resulting in lower activation costs.

In sensitivity 1, consumer costs are close to those of the base case, following the same trend as the activation costs

Consumer costs split – 2030 – Base Case



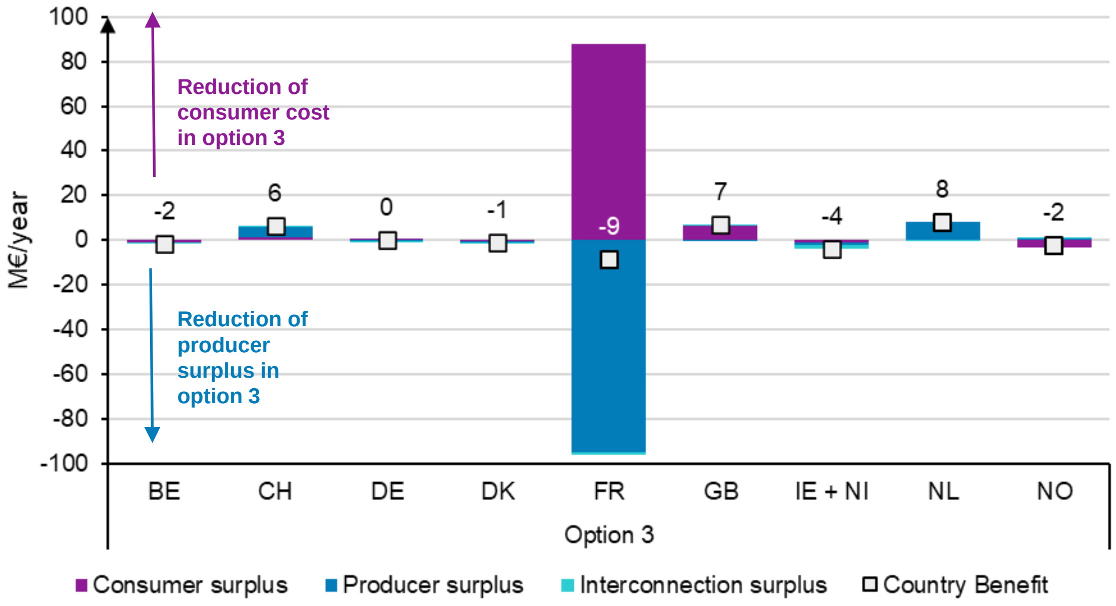
Consumer costs split – 2030 – sensitivity 1



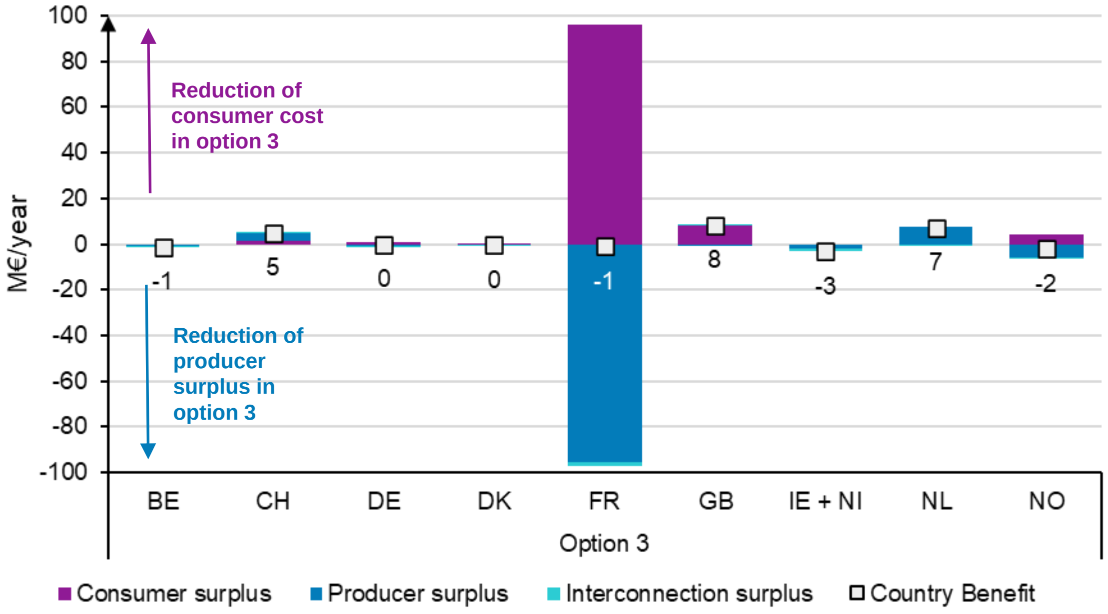
- Similarly to activation costs, **consumer costs in sensitivity 1 are close to those of the base case** with a slight increase in the counterfactual and option 1 and a slight decrease in option 3 and 5.
- The **counterfactual leads to higher costs for consumers**.
- **Cross-border balancing options lead to a significant reduction** of consumer costs, because of **the rules for allocating demand between UK CBB and TERRE / MARI platforms and to price formation.** As explained previously, the **reduction of demand in EU platforms** (and UK domestic markets) together with the sharing of the less expensive offers lead to a price reduction in the EU platforms, hence applied to large volume. This **reduction in prices in these platforms largely exceeds the similar or slightly higher prices in the UK CBB platform**.

In sensitivity 1, the distribution of benefits between countries follows the same trend as in the base case

Country costs/benefits – Base case, 2030, option 3 vs counterfactual



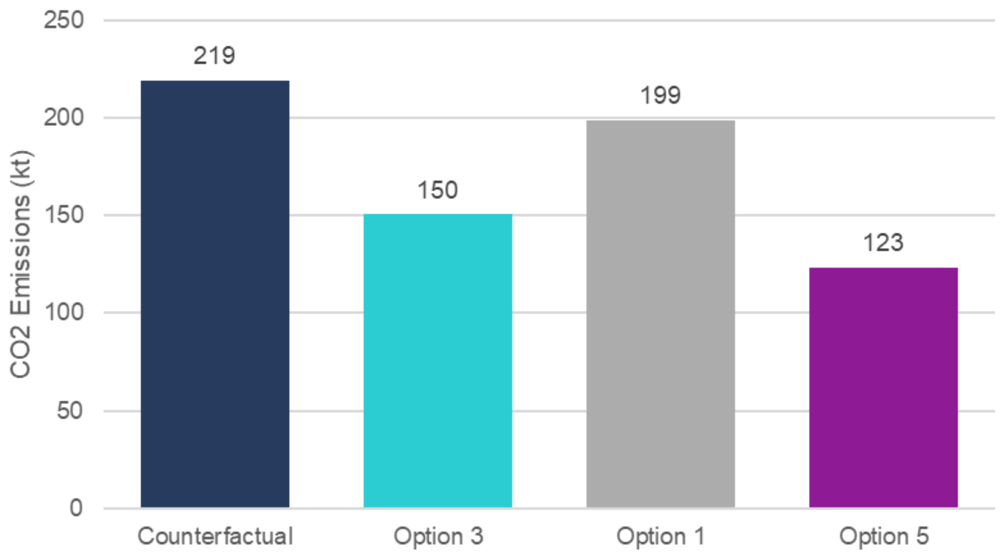
Country costs/benefits – sensitivity 1, 2030, option 3 vs counterfactual



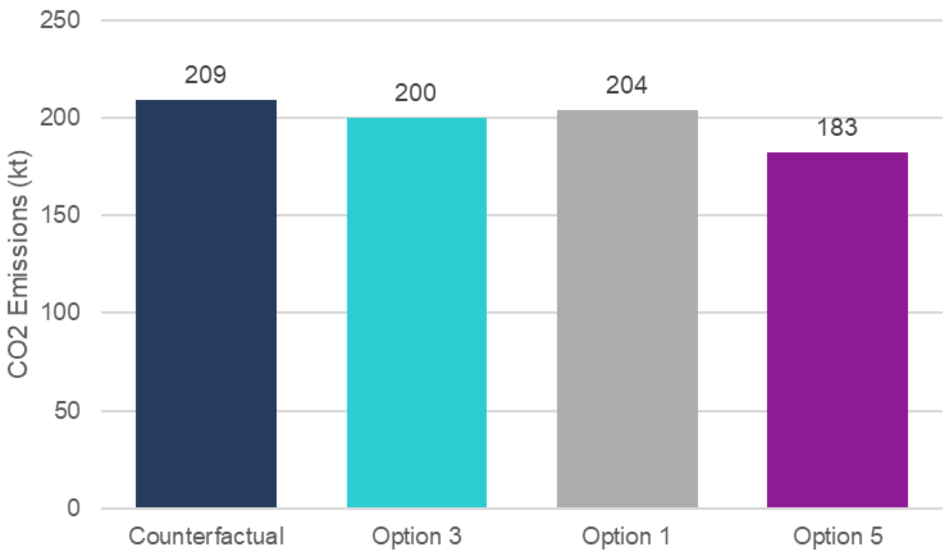
- In option 3, sharing bids between Great Britain, Switzerland and other European countries decrease the French consumer cost (positive consumer surplus) but decrease the surplus for French producers, **resulting in a country benefit of -1M€ for France.**
- **Compared to the base case, there is an increase of 8M€ in the country benefit in France** in sensitivity 1 which is related to an increase in the consumer surplus.
- The **country benefit remains very close between the base case and sensitivity 1 in Great Britain, positive by 8M€ in sensitivity 1,** mainly due to the consumer surplus related to lower activation costs.

In sensitivity 1, reduction in CO_2 emissions by options follow the same trend as in the base case, but to a lesser extent

CO_2 emissions – Base case - 2030



CO_2 emissions – Sensitivity 1 - 2030



- In sensitivity 1, **reduction in CO_2 emissions follow the same trend as in the base case, but to a lesser extent**
- **As in the base case, option 5 seems to offer the greatest reduction in CO_2 emissions**, but subject to the same limitations in the technical possibility of merging merit orders of two different products.
- However, **CO_2 emissions levels avoided by these options remain quite low when compared to the overall emissions of the power system, of the order of 200Mt in 2030 in our power dispatch model.**

Note: CO_2 emissions for downward reserves are represented in negative because the downward activation corresponds to a decrease in production, thus a reduction in emissions for thermal power plants.

3.2

Modelling and Cost-Benefit Analysis of sensitivities

2. Sensitivity 2 – UK interconnection capacity of 25GW from 2030

Sensitivity 2 – Description of the sensitivity

Description of the sensitivity:

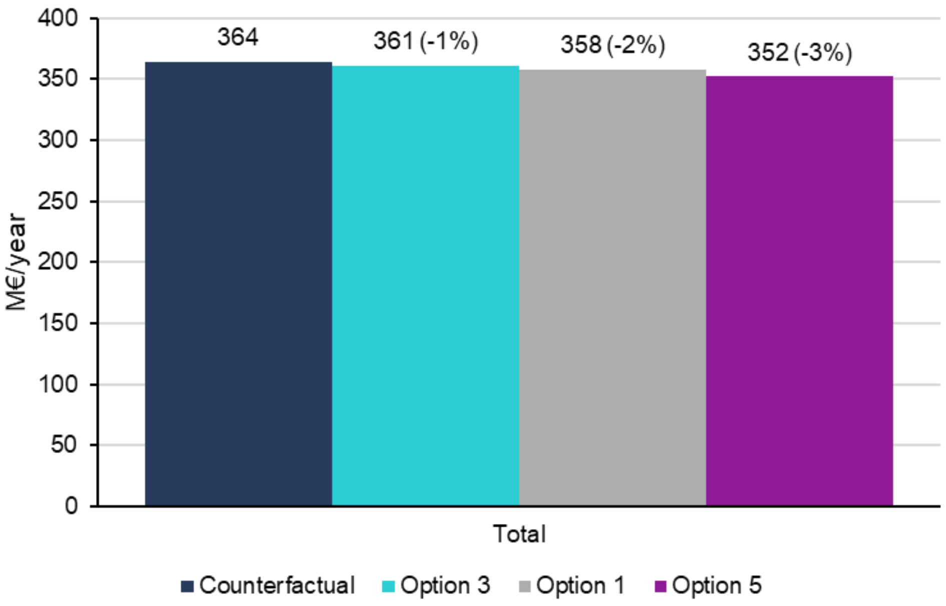
- We use an UK interconnection capacity of 25GW in 2030 instead of 13GW in the base case.

Impact on prices compared to the base case (GB and interconnected countries – yearly average):

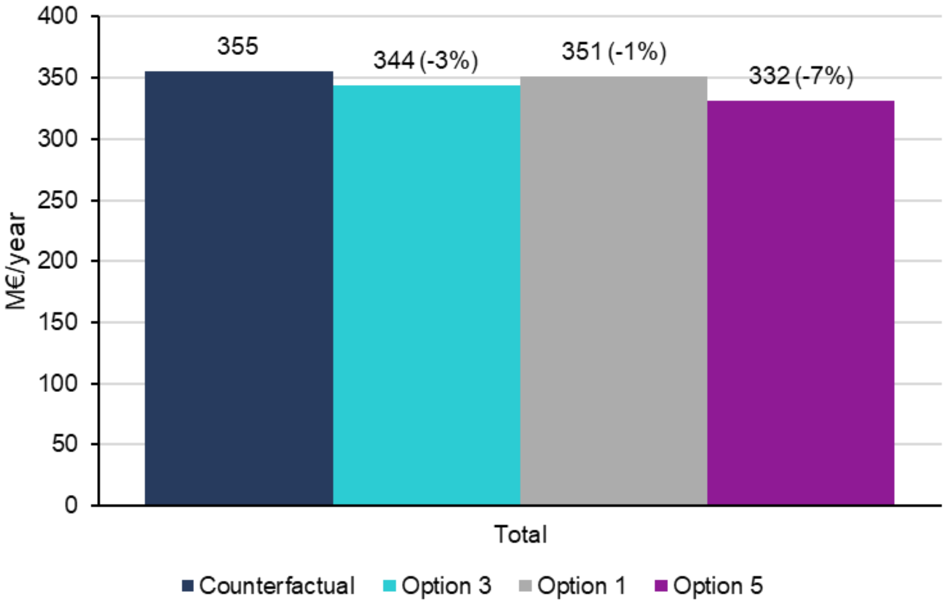
Year	2030	
Scenario	Base Case	Sensitivity 2
GB	49.3	58.6
FR	69.9	66.2
DE	83.7	80.4
BE	74.3	66.6
NL	62.7	60.9
NO2	33.9	41.2
IE	53.6	57.9

In sensitivity 2, activation cost decreases thanks to a better resource allocation

Activation cost – Base Case - 2030



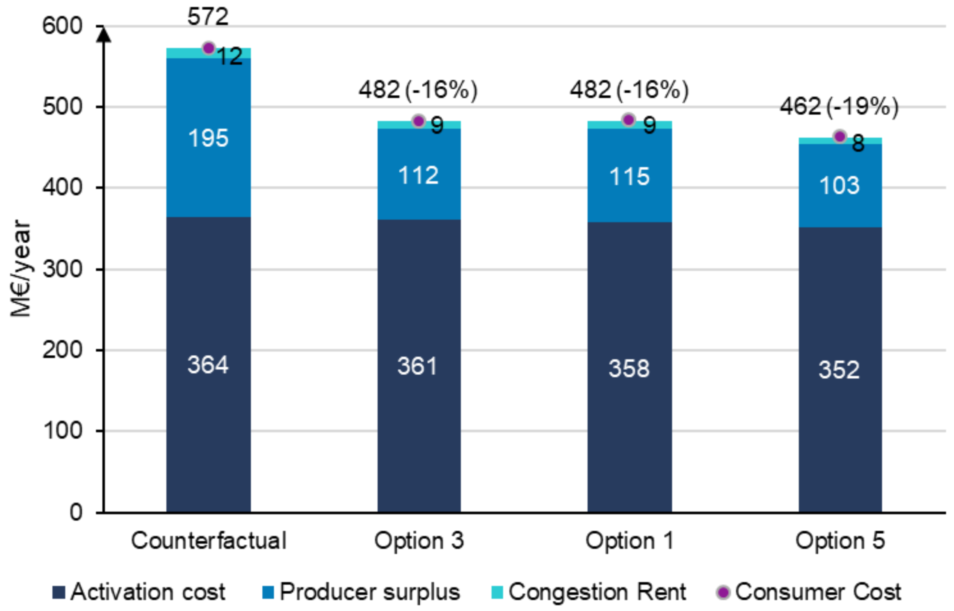
Activation cost – sensitivity 2 - 2030



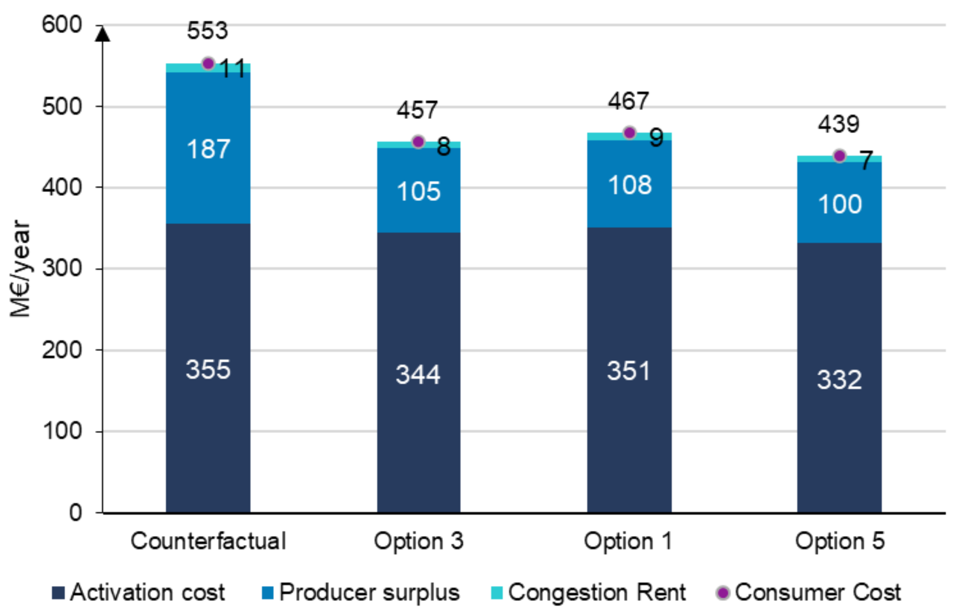
- **In the counterfactual, activation costs in sensitivity 2 are lower than in the base case** because the increase in interconnector capacity allows a better allocation of resources in the area.
- **Activation costs also decrease in options 1, 3 and 5 but remain close to those of the counterfactual.**

In sensitivity 2, consumer costs are close to those of the base case, following the same trend as the activation costs

Consumer costs split – 2030 – Base Case



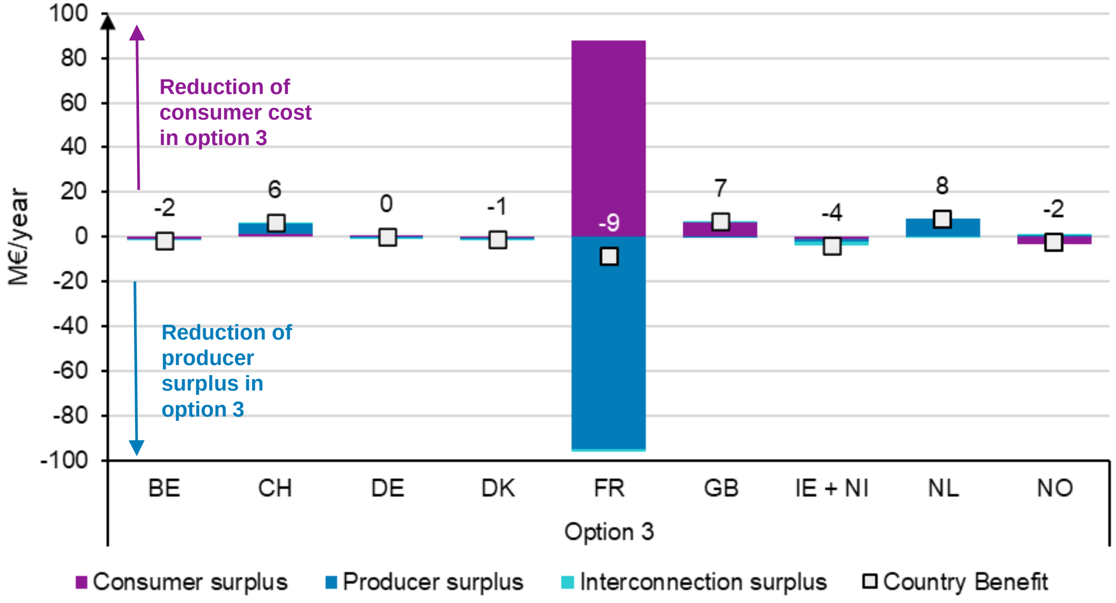
Consumer costs split – 2030 – sensitivity 2



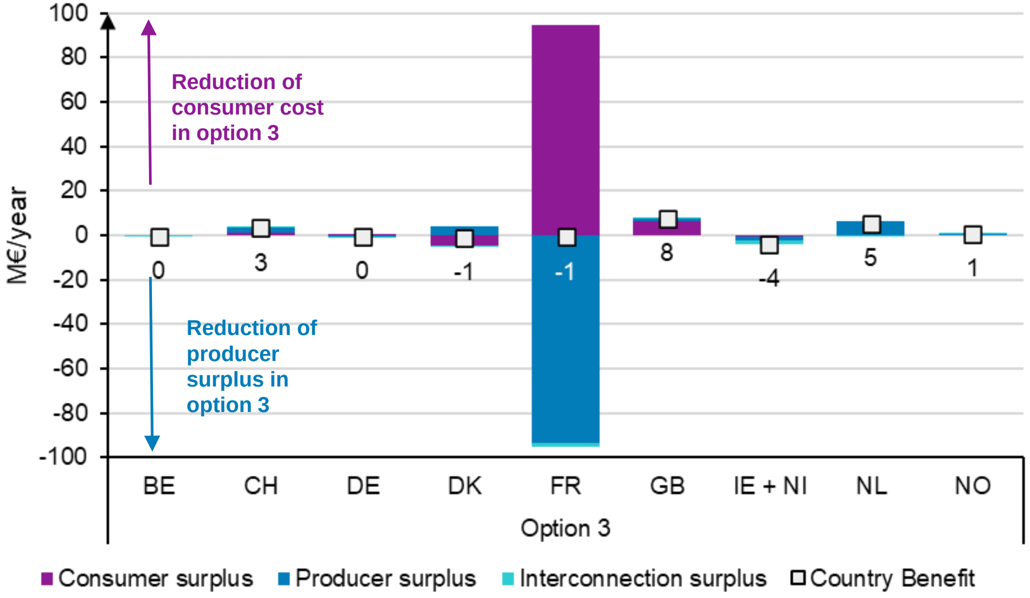
- Similarly to activation costs**, consumer costs in sensitivity 2 are close to those of the base case with a decrease in option 3 and 5** thanks to a better resource allocation with the increase in interconnector capacity.
- The **counterfactual leads to higher costs for consumers**.
- **Cross-border balancing options lead to a significant reduction** of consumer costs, because of **the rules for allocating demand between UK CBB and TERRE / MARI platforms and to price formation.** As explained previously, the **reduction of demand in EU platforms** (and UK domestic markets) together with the sharing of the less expensive offers lead to a price reduction in the EU platforms, hence applied to large volume. This **reduction in prices in these platforms largely exceeds the similar or slightly higher prices in the UK CBB platform**.

In sensitivity 2, the distribution of benefits between countries follows the same trend as in the base case

Country costs/benefits – Base case, 2030, option 3 vs counterfactual



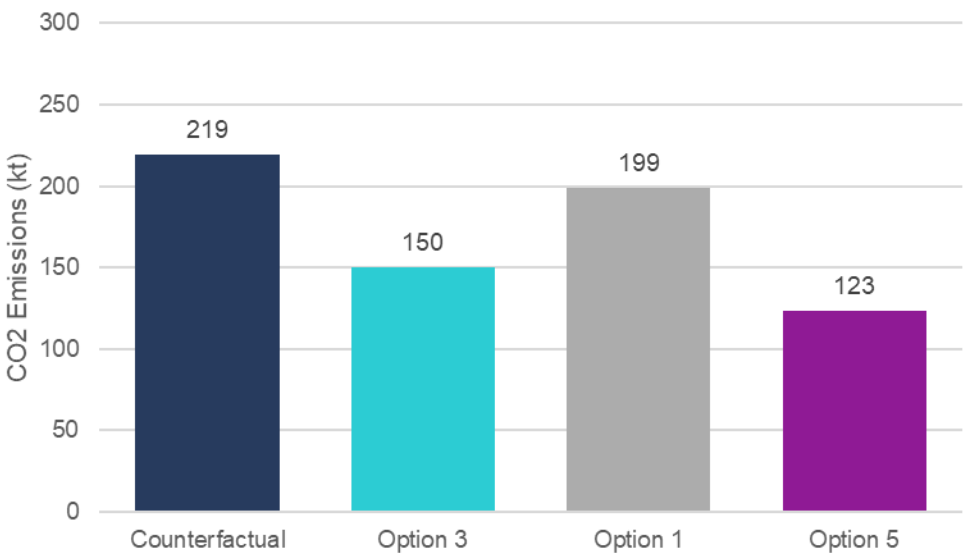
Country costs/benefits – Sensitivity 2, 2030, option 3 vs counterfactual



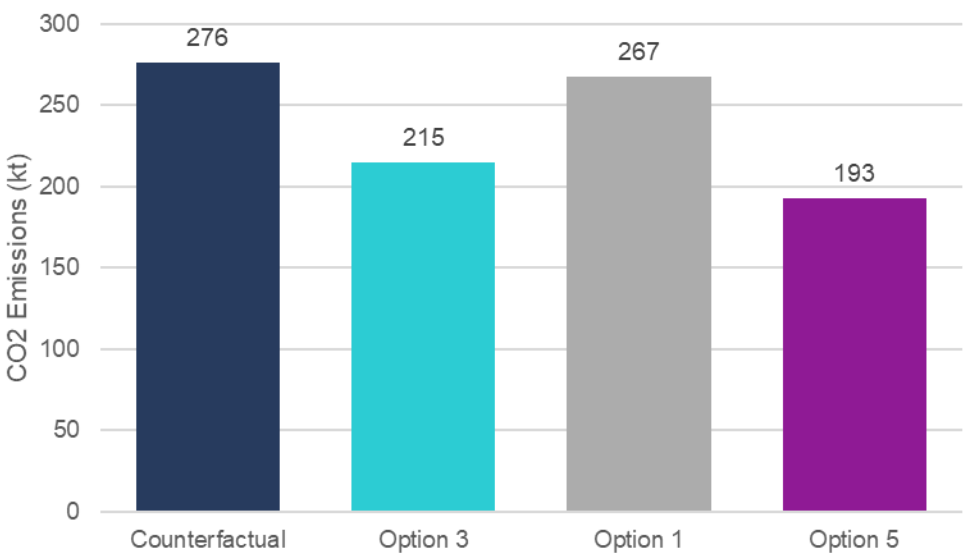
- Compared to the counterfactual, option 3 will lead to a significant positive consumer surplus in France in sensitivity 2 but conversely will lead to a significant reduction in the producer surplus in France. As a result, the **country benefit in France is negative around -1M€.**
- Compared to the base case, **there is an increase of 8M€ in the country benefit in France** in sensitivity 2 which is related to an increase in the consumer surplus.
- The **country benefit remains very close between the base case and sensitivity 2 in Great Britain, positive by 8M€ in sensitivity 2,** mainly due to the consumer surplus related to lower activation costs.

In sensitivity 2, reduction in CO_2 emissions by options follow the same trend as in the base case

CO_2 emissions – Base case - 2030



CO_2 emissions – Sensitivity 2 - 2030



- In sensitivity 2, **reduction in CO_2 emissions by options follow the same trend as in the base case,** but with higher CO_2 emissions for the counterfactual and all options.
- Indeed, in this sensitivity, the better allocation of resources with the increase in interconnections leads to a decrease in the share of thermal power in the power dispatch model, resulting in fewer thermal offers available in downward mFRR and downward RR.
- **As in the base case, option 5 seems to offer the greatest reduction in CO_2 emissions**, but subject to the same limitations in the technical possibility of merging merit orders of two different products.

Note: CO_2 emissions for downward reserves are represented in negative because the downward activation corresponds to a decrease in production, thus a reduction in emissions for thermal power plants.

3.3

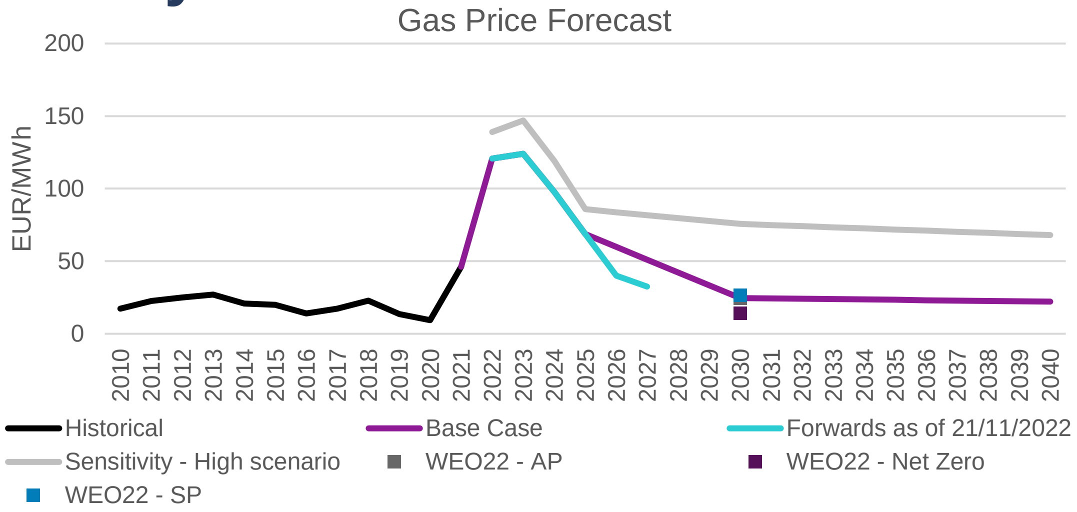
Modelling and Cost-Benefit Analysis of sensitivities

3. Sensitivity 3 – High gas prices in the long term

Sensitivity 3 – Description of the sensitivity

Description of the sensitivity:

- Due to a gas shortage in Europe because of the war in Ukraine, gas prices will remain high in the long term, with gas imports remaining low and relying mainly on LNG imports. We propose to use our high internal scenario for gas price presented in the chart below in grey price based on US HH gas price projections to which we add LNG liquefaction and transport costs.

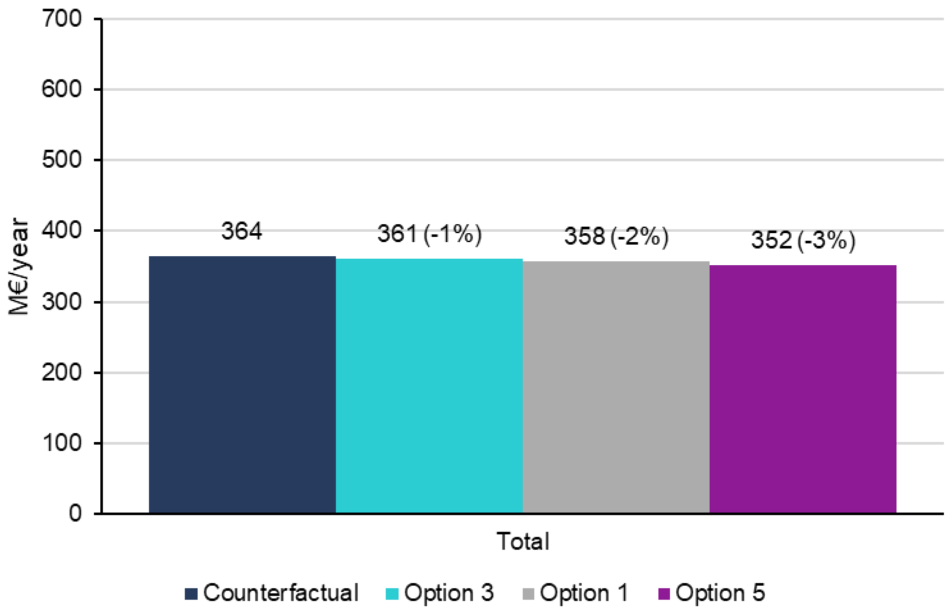


Impact on prices compared to the base case (GB and interconnected countries – yearly average):

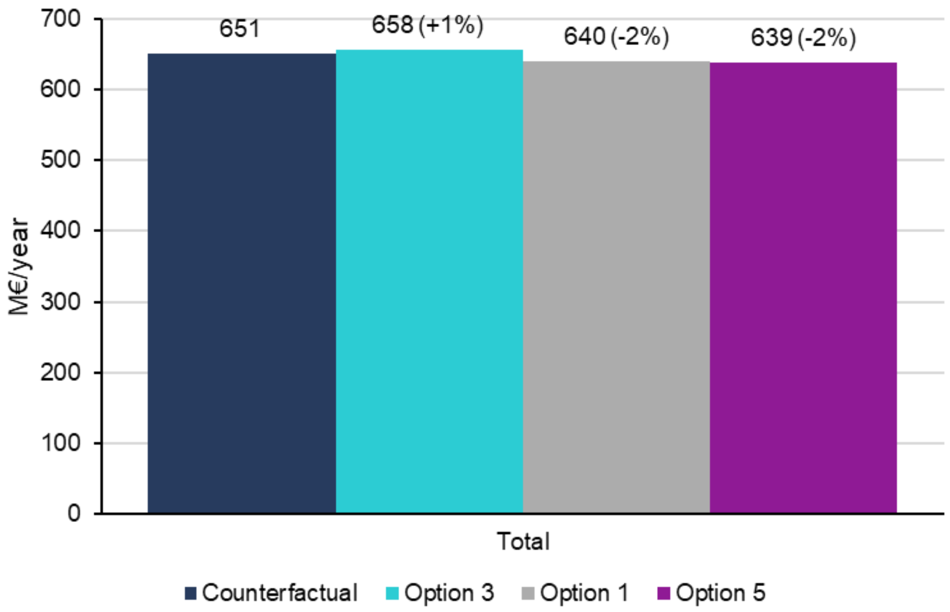
Year	2030	
Scenario	Base Case	Sensitivity 3
GB	49.3	95.5
FR	69.9	127.0
DE	83.7	160.3
BE	74.3	141.9
NL	62.7	119.6
NO2	33.9	58.7
IE	53.6	105.9

In sensitivity 3, increase in commodity prices leads to significant increase in balancing costs, but does not change the ranking of CBB options

Activation cost – Base Case - 2030



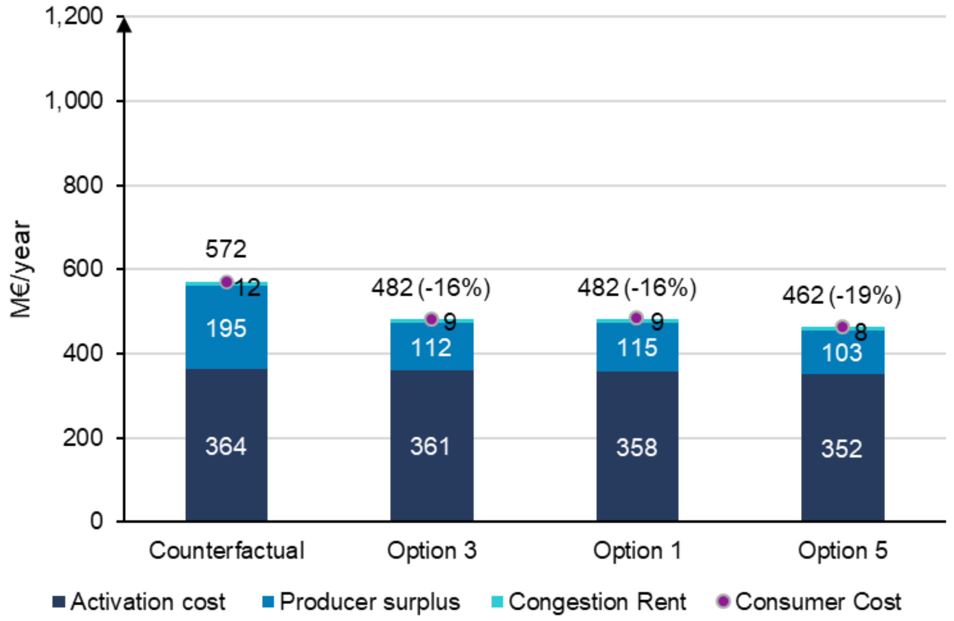
Activation cost – sensitivity 3 - 2030



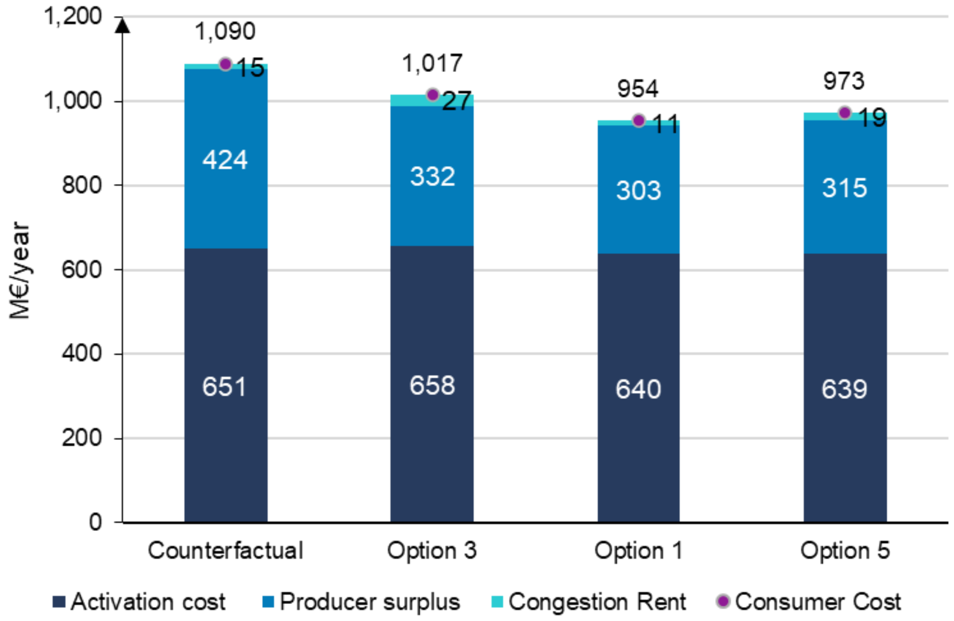
- **Increase in commodity prices leads to higher balancing costs in absolute.**
- In sensitivity 3, options 1 and 5 provide a slightly better cost reduction compared to option 3, since the activation costs of option 3 are even higher than those of the counterfactual.
- The **ranking of the various options remain similar**: cross-border balancing options not based on the participation of GB in EU platforms do not lead to a significant reduction of balancing activation costs.

In sensitivity 3, consumer costs of cross-border balancing options are lower than those of the counterfactual

Consumer costs split – 2030 – Base Case



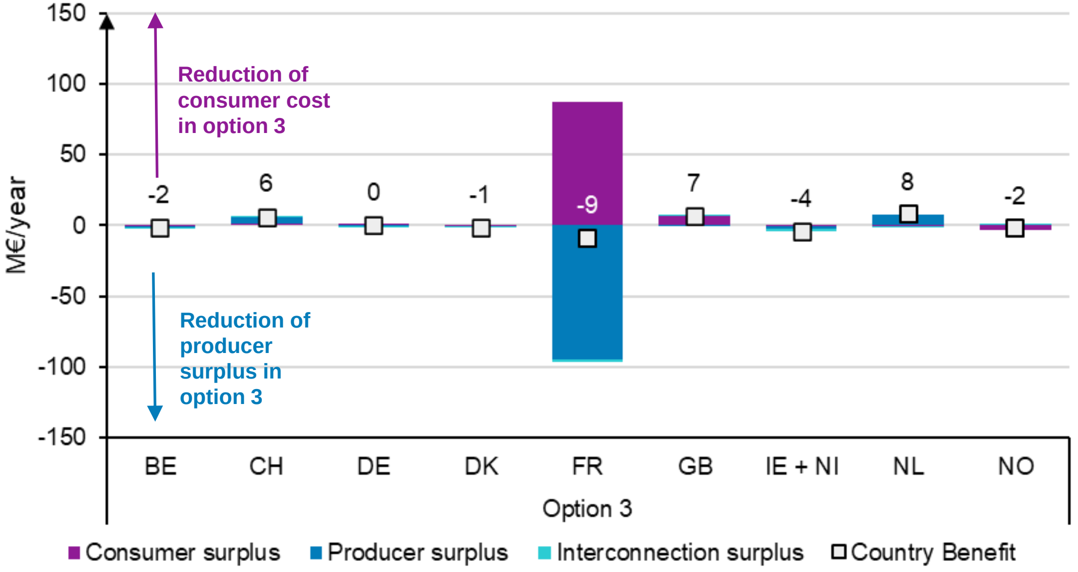
Consumer costs split – 2030 – sensitivity 3



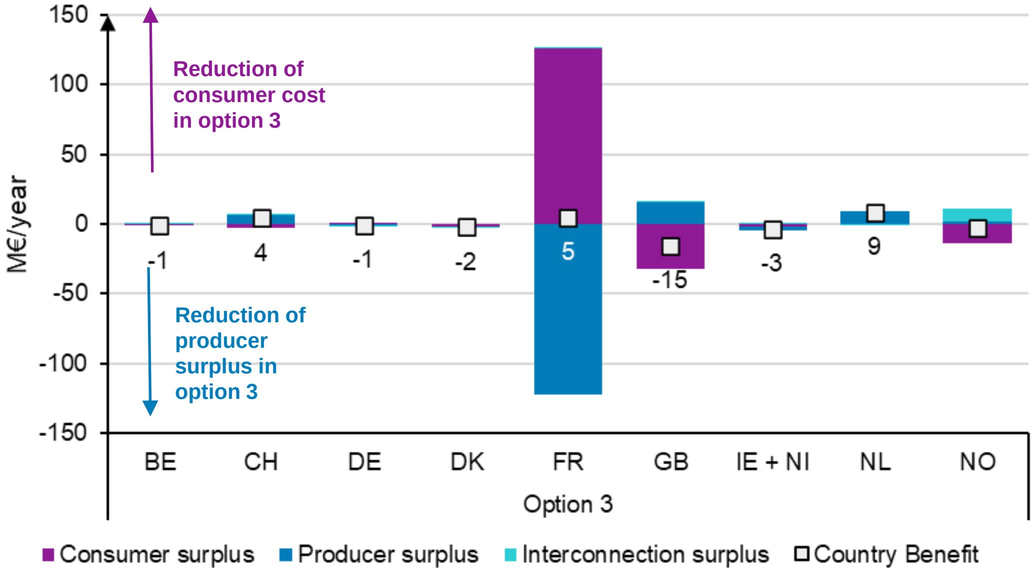
- Similarly to activation costs, increase in commodity prices **resulting in higher consumer costs**.
- The **counterfactual leads to higher costs for consumers**.
- **Cross-border balancing options lead to a significant reduction** of consumer costs, because of **the rules for allocating demand between UK CBB and TERRE / MARI platforms and to price formation.** As explained previously, the **reduction of demand in EU platforms** (and UK domestic markets) together with the sharing of the less expensive offers lead to a price reduction in the EU platforms, hence applied to large volume. This **reduction in prices in these platforms largely exceeds the similar or slightly higher prices in the UK CBB platform**.

In sensitivity 3, the distribution of benefits between countries follows the same trend as in the base case

Country costs/benefits – Base Case, option 3 vs counterfactual



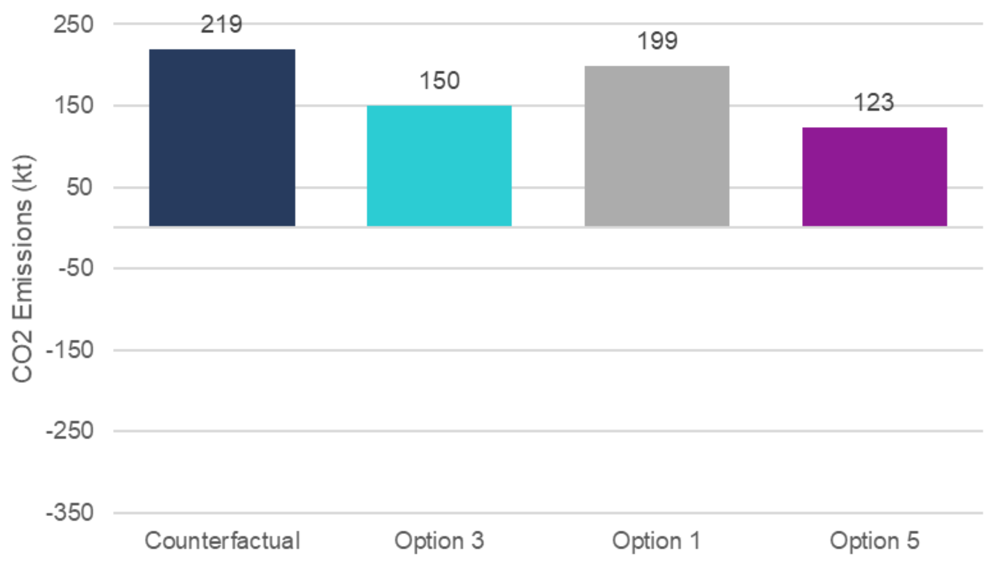
Country costs/benefits – Sensitivity 3, option 3 vs counterfactual



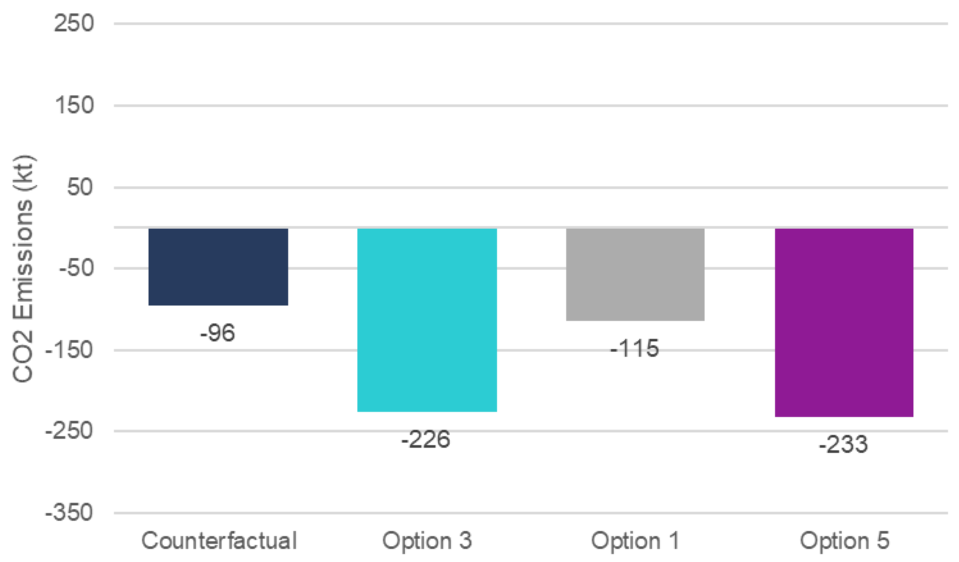
- Compared to the counterfactual, **option 3 will again increase the consumer surplus in France** and **reduce the producer surplus in sensitivity 3** but to a **higher extent** than in the base with a significant increase of the consumer surplus. In the end, the **country benefit for France increases to reach +5M€.**
- On the contrary, in option 3, sharing bids between Great Britain, Switzerland and other European countries increase the British consumer cost (negative consumer surplus) but increase the surplus for British producers, **resulting in a country benefit of -15M€ for Great Britain.**

In sensitivity 3, reduction in CO2 emissions by options follow the same trend as in the base case

CO2 emissions – Base case - 2030



CO2 emissions – Sensitivity 3 - 2030



- In sensitivity 3, **reduction in CO2 emissions by options follow the same trend as in the base case,** but with lower CO2 emissions for the counterfactual and all options, CO2 emissions of mFRR and RR activation even becoming negative.
- Indeed, in this sensitivity, high gas price means expensive bids from gas plants in upward mFRR and upward RR, resulting in the favouring of other decarbonised technologies such as hydro. Conversely, in downward mFRR and downward RR, gas-fired power plants are favoured because they offer high price to buy back their electricity.
- **As in the base case, option 5 seems to offer the greatest reduction in CO2 emissions**, but subject to the same limitations in the technical possibility of merging merit orders of two different products.

Note: CO2 emissions for downward reserves are represented in negative because the downward activation corresponds to a decrease in production, thus a reduction in emissions for thermal power plants.

3.4

Modelling and Cost-Benefit Analysis of sensitivities

4. Sensitivity 4 – More renewables in European countries

Sensitivity 4 – Description of the sensitivity

Description of the sensitivity:

➢ We consider more renewables in European countries:

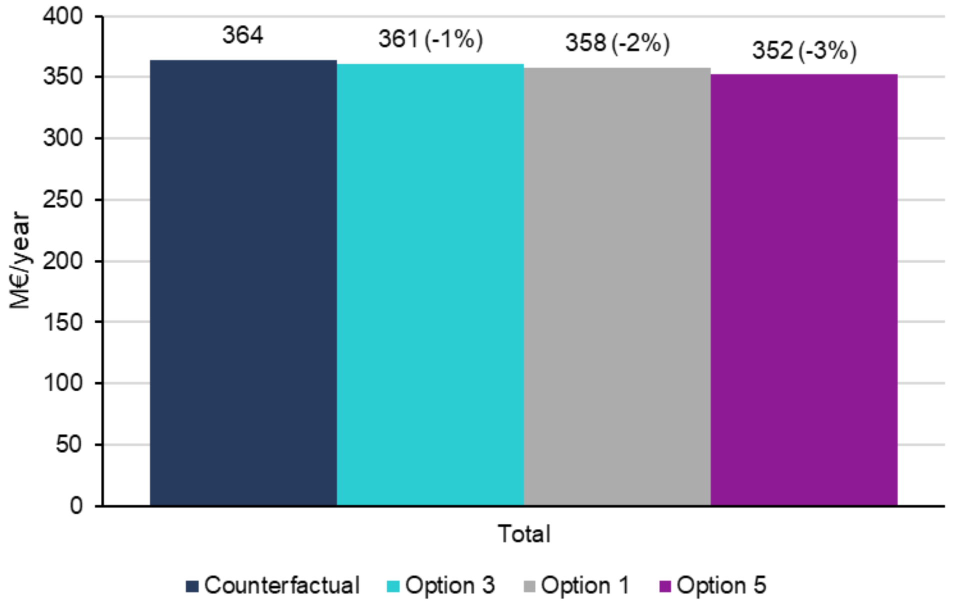
- **more offshore wind in Norway**: 30GW by 2040 instead of 4.3GW following NSEC joint statement Sep 2022. We consider 4.5GW in 2030 as only two projects of 3 and 1.5GW are mentioned in NGPD 2021 and could thus be operational by 2030.
- **more offshore wind in Sweden**: 15GW by 2040 instead of 5.5GW following NGDP 2021. We consider 5GW in 2030 following NGDP 2021.
- **more onshore wind in Germany**: 160GW by 2040 instead of 113GW following EEG 2023 (German Renewable Energy Sources Act 2023). We consider 115GW in 2030 following EEG 2023.
- **more solar in Germany**: 266GW by 2040 instead of 133GW taking the average of the EEG 2023 target (400GW) and the TYNDP GA (133GW). We consider 141GW by 2030 taking the average of the EEG 2023 target (215GW) and the TYNDP GA (67GW).

Impact on prices compared to the base case (GB and interconnected countries – yearly average):

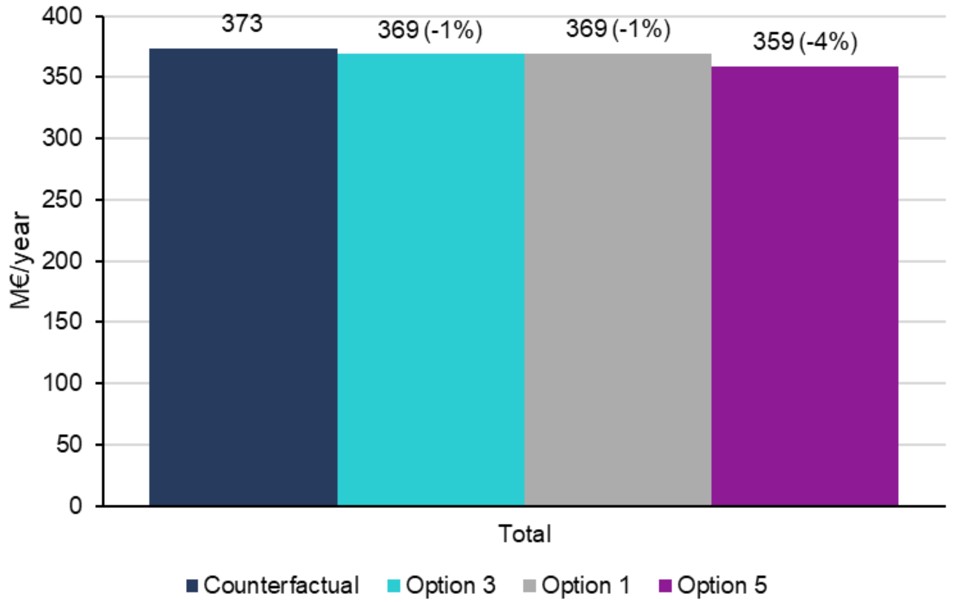
Year	2030	
Scenario	Base Case	Sensitivity 4
GB	49.3	44.1
FR	69.9	61.7
DE	83.7	57.5
BE	74.3	63.5
NL	62.7	51.8
NO2	33.9	21.8
IE	53.6	49.8

In sensitivity 4, activation cost increases slightly, but does not change the ranking of CBB options

Activation cost – Base Case - 2030



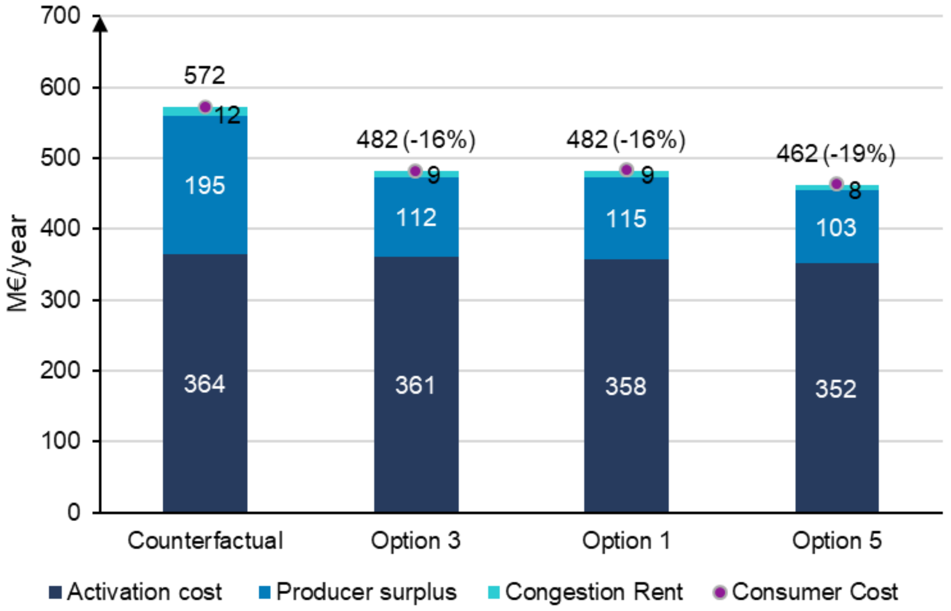
Activation cost – sensitivity 4 - 2030



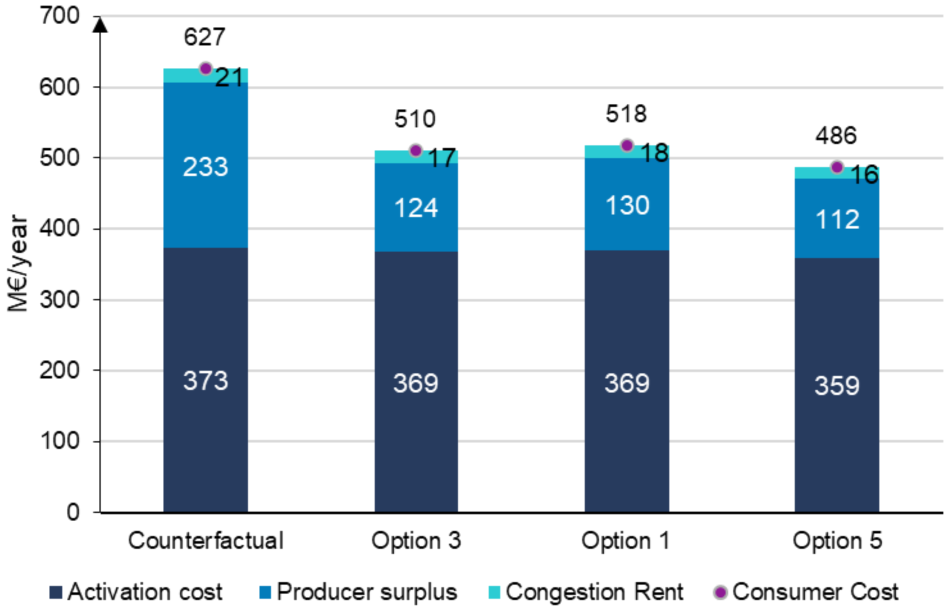
- In sensitivity 4, **increase in renewable capacity leads to less use of thermal capacity** in the power model and fewer offers from thermal power plants to buy back their power in downward mFRR and RR, resulting in in **lower revenues in downward mFRR and RR** and **higher activation costs overall.**
- The **ranking of the various options remain similar**: cross-border balancing options not based on the participation of GB in EU platforms do not lead to a significant reduction of balancing activation costs.

In sensitivity 4, consumer costs of cross-border balancing options are lower than those of the counterfactual

Consumer costs split – 2030 – Base Case



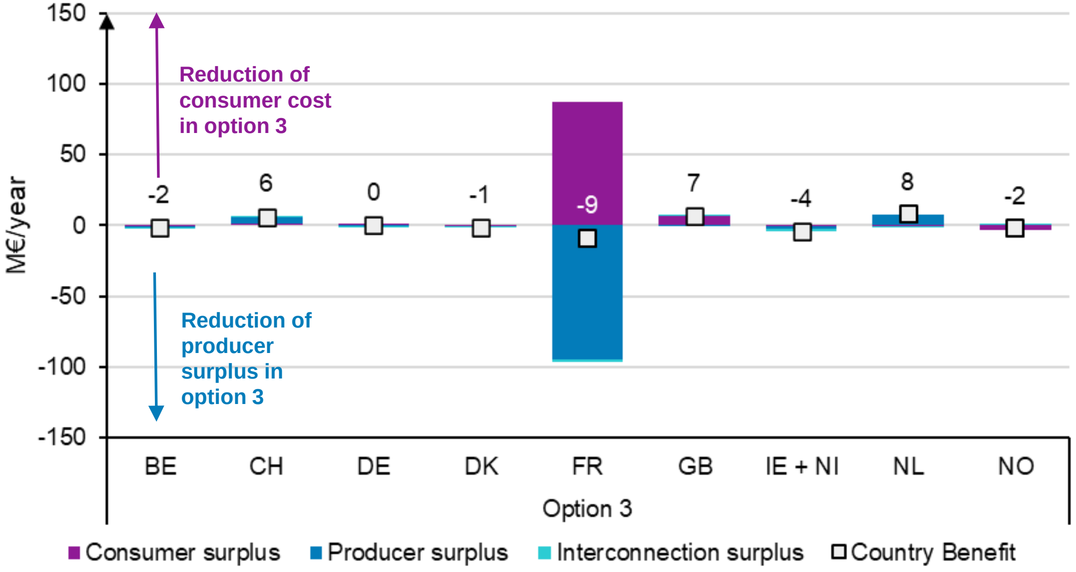
Consumer costs split – 2030 – Sensitivity 4



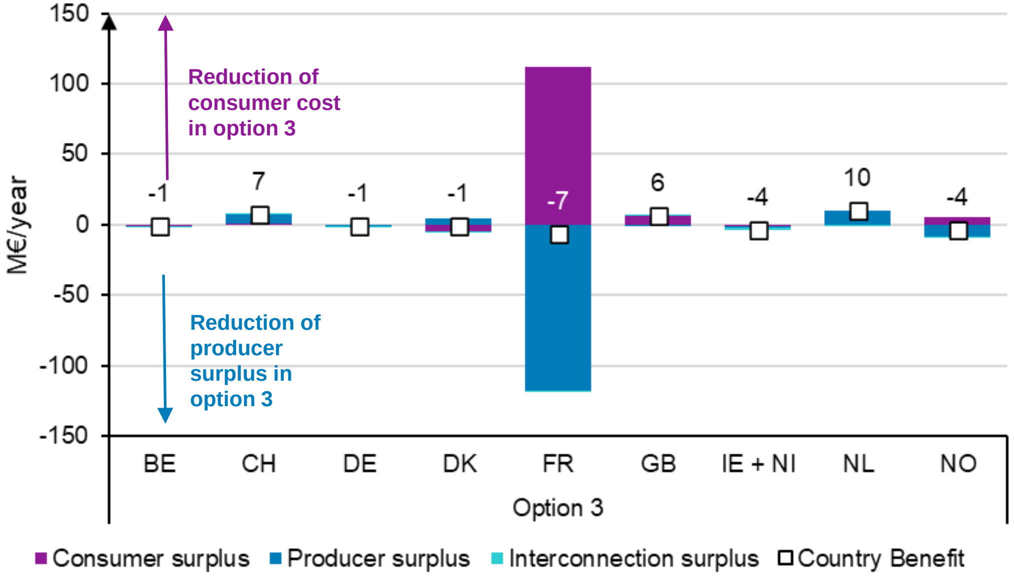
- Similarly to activation costs, **consumer costs are higher in sensitivity 4 than in the base case.**
- The **counterfactual leads to higher costs for consumers**.
- **Cross-border balancing options lead to a significant reduction** of consumer costs, because of **the rules for allocating demand between UK CBB and TERRE / MARI platforms and to price formation.** As explained previously, the **reduction of demand in EU platforms** (and UK domestic markets) together with the sharing of the less expensive offers lead to a price reduction in the EU platforms, hence applied to large volume. This **reduction in prices in these platforms largely exceeds the similar or slightly higher prices in the UK CBB platform**.

In sensitivity 4, the distribution of benefits between countries follows the same trend as in the base case

Country costs/benefits – Base Case, option 3 vs counterfactual



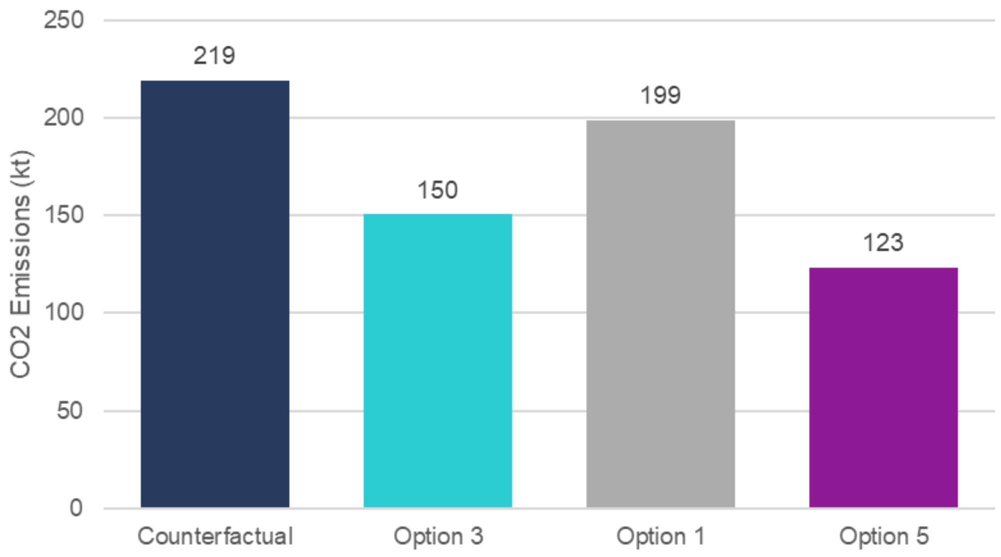
Country costs/benefits – Sensitivity 4, option 3 vs counterfactual



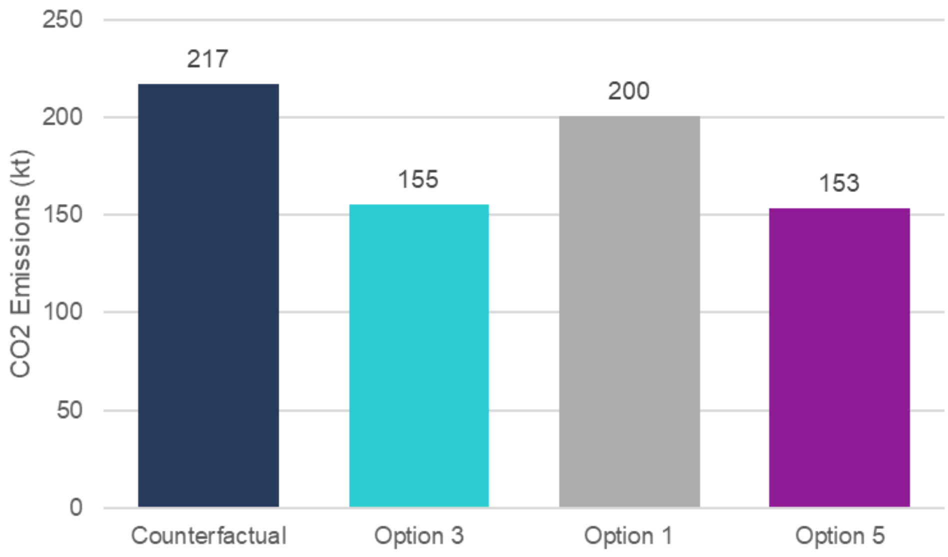
- Compared to the counterfactual, **option 3 will lead to a significant consumer surplus in France** in sensitivity 4 but conversely will lead to **a significant reduction in the producer surplus in France**. As a result, the **country benefit in France is negative around -7M€ in sensitivity 4.**
- The **country benefit remains very close between the base case and sensitivity 2 in Great Britain, positive by 6M€ in sensitivity 4,** mainly due to the consumer surplus related to lower activation costs.

In sensitivity 4, reduction in CO_2 emissions by options are close to those of the base case

CO_2 emissions – Base case - 2030



CO_2 emissions – Sensitivity 4 - 2030



- In sensitivity 4, **reduction in CO_2 emissions by options are close to those of the base case.**
- **Option 3 and 5 seem to offer the greatest reduction in CO_2 emissions.**
- However, **CO_2 emissions levels avoided by these options remain quite low when compared to the overall emissions of the power system, of the order of 200Mt in 2030 in our power dispatch model.**

Note: CO_2 emissions for downward reserves are represented in negative because the downward activation corresponds to a decrease in production, thus a reduction in emissions for thermal power plants.

3.5

Modelling and Cost-Benefit Analysis of sensitivities

5. Sensitivity 5 – Increased involvement of new technologies

Sensitivity 5 – Description of the sensitivity

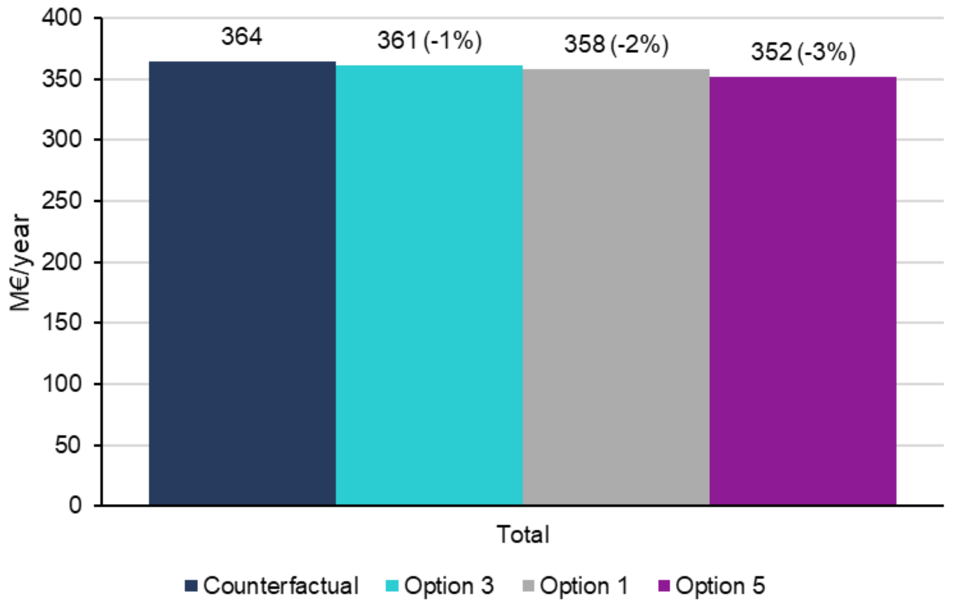
Description of the sensitivity:

- We consider the involvement of new technologies to be twice as high in terms of proposed volumes as in the base case.
- We also consider that the premium applied on the activation price bids is reduced by half.

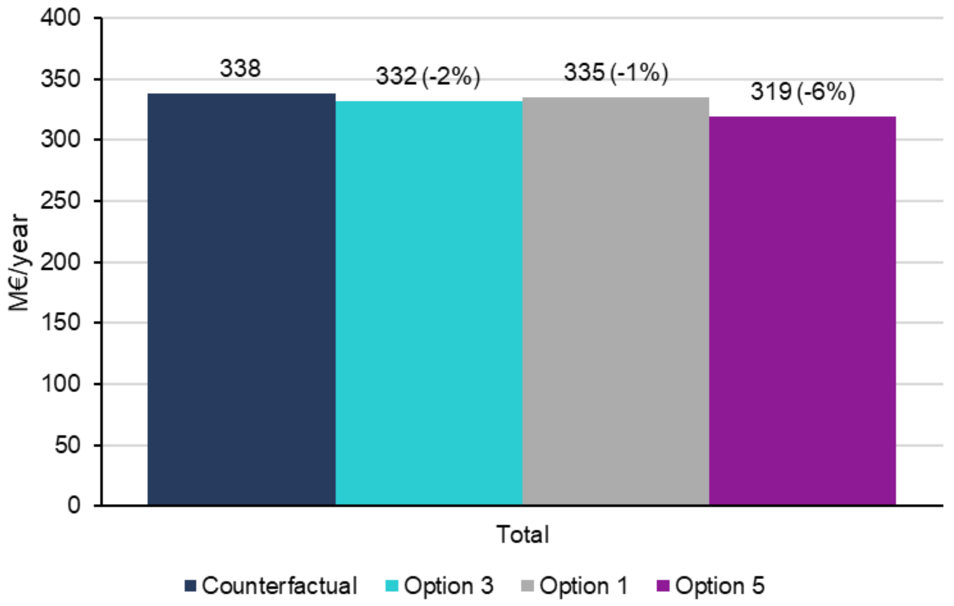
New Technology	Volume being able to participate in the base case	Volume being able to participate in the sensitivity 5	Activation price bids in the base case	Activation price bids in sensitivity 5
BTM Batteries & EVs (Electric Vehicles)	**5%** of the hourly consumption (Up)	**10%** of the hourly consumption (Up) **5%** of the hourly consumption within the limit of the max power (Down)	Up : Monthly **power price + 100€/MWh**	Up : Monthly **power price + 50€/MWh** **Down : 50€/MWh -** Monthly **power price**
RES (Renewables)	Only renewables units that do not have a support contract: **15%** of the hourly consumption (Down)	Only renewables units that do not have a support contract: **30%** of the hourly consumption (Down)	Renewables have no interest in buying back their electricity, so we consider that they bid **0€/MWh** in down.	Renewables have no interest in buying back their electricity, so we consider that they bid **0€/MWh** in down.
P2G (Power-to-Gas)	**5%** of the hourly consumption (Up)	**10%** of the hourly consumption (Up) **5%** of the hourly consumption within the limit of the max power (Down)	Up : Monthly **power price + 200€/MWh**	Up : Monthly **power price + 50€/MWh** **Down : 50€/MWh -** Monthly **power price**
HP (Heat Pumps)	**5%** of the hourly consumption (Up)	**10%** of the hourly consumption (Up) **5%** of the hourly consumption within the limit of the max power (Down)	Up : Monthly **power price + 100€/MWh**	Up : Monthly **power price + 50€/MWh** **Down : 50€/MWh -** Monthly **power price**

In sensitivity 5, activation costs decrease with more new technologies at a lower price in upward mFRR and RR and participation of Electric Vehicles, Heat Pumps and Power-to-gas in downward mFRR and RR

Activation cost – Base Case - 2030



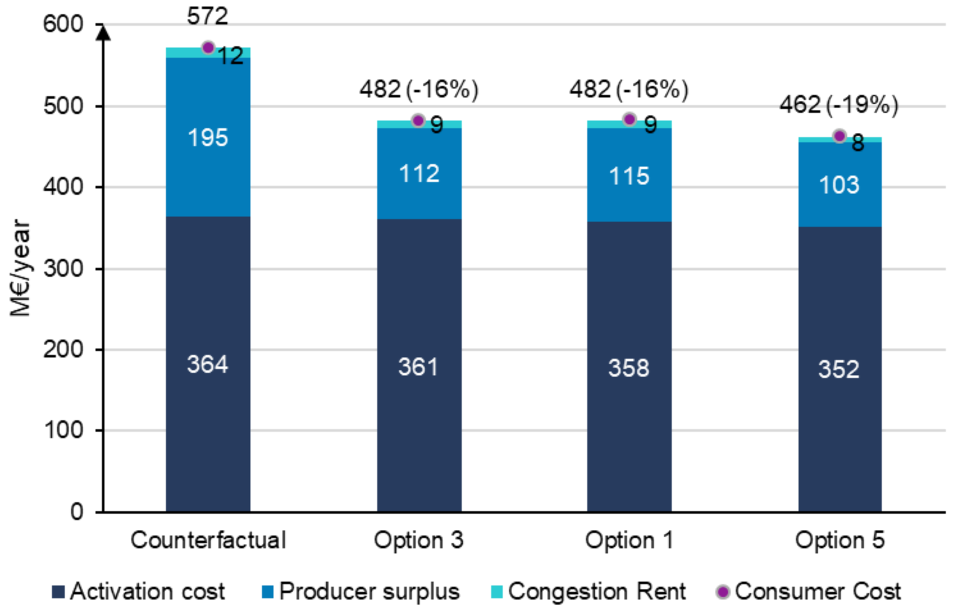
Activation cost – sensitivity 5- 2030



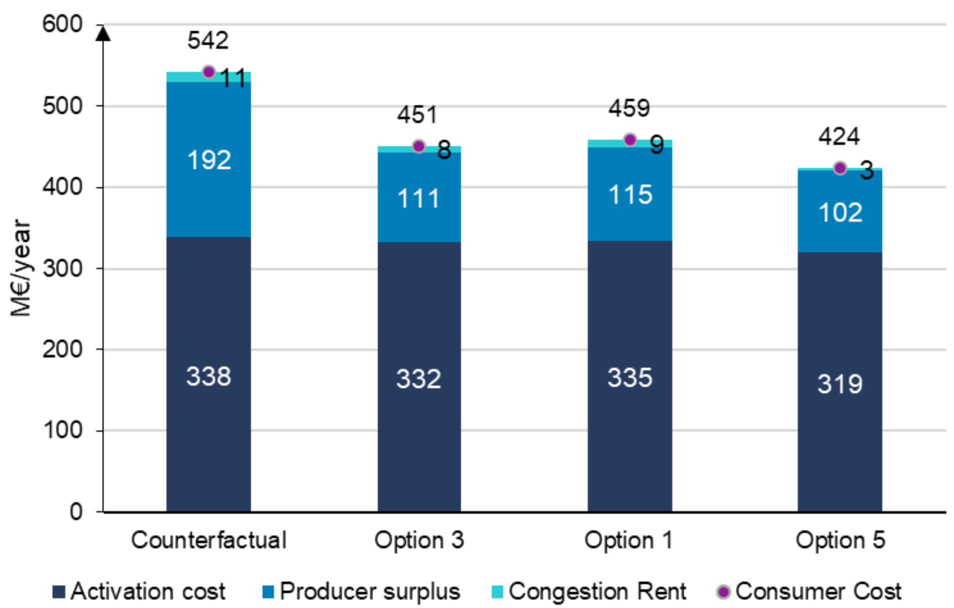
- In **upward mFRR and RR**, the **doubling of the volume of new technologies** and **at a lower price bid** resulting in **lower costs**.
- In **downward mFRR and RR**, the participation of Electric Vehicles, Heat Pumps and Power-to-Gas in Down **resulting in higher revenues.**
- As a result, the decrease in upward mFRR and RR costs and the increase in downward mFRR and RR revenues **lead to a decrease in activation costs**.
- Similarly to the base case, the **activation costs of options 1, 3 and 5 remain close** to those of the counterfactual in this sensitivity 5.

In sensitivity 5, consumer costs are close to those of the base case, following the same trend as the activation costs

Consumer costs split – 2030 – Base Case



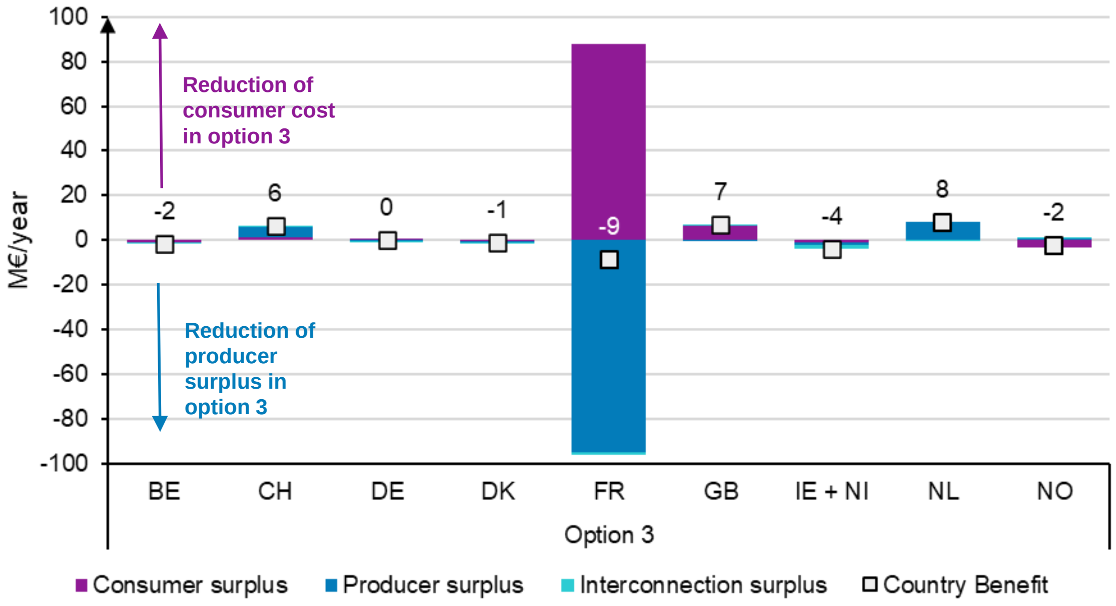
Consumer costs split – 2030 – sensitivity 5



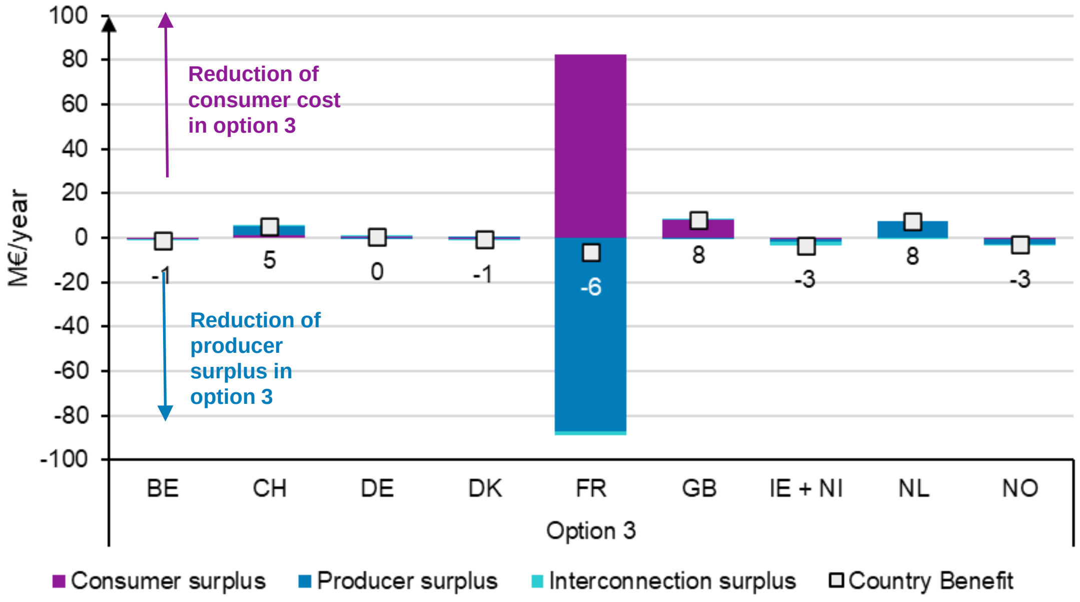
- Similarly to activation costs, **consumer costs are lower in sensitivity 5 than in the base case.**
- The **counterfactual leads to higher costs for consumers**.
- **Cross-border balancing options lead to a significant reduction** of consumer costs, because of **the rules for allocating demand between UK CBB and TERRE / MARI platforms and to price formation.** As explained previously, the **reduction of demand in EU platforms** (and UK domestic markets) together with the sharing of the less expensive offers lead to a price reduction in the EU platforms, hence applied to large volume. This **reduction in prices in these platforms largely exceeds the similar or slightly higher prices in the UK CBB platform**.

In sensitivity 5, the distribution of benefits between countries follows the same trend as in the base case

Country costs/benefits – 2030 – Base Case, option 3 vs counterfactual



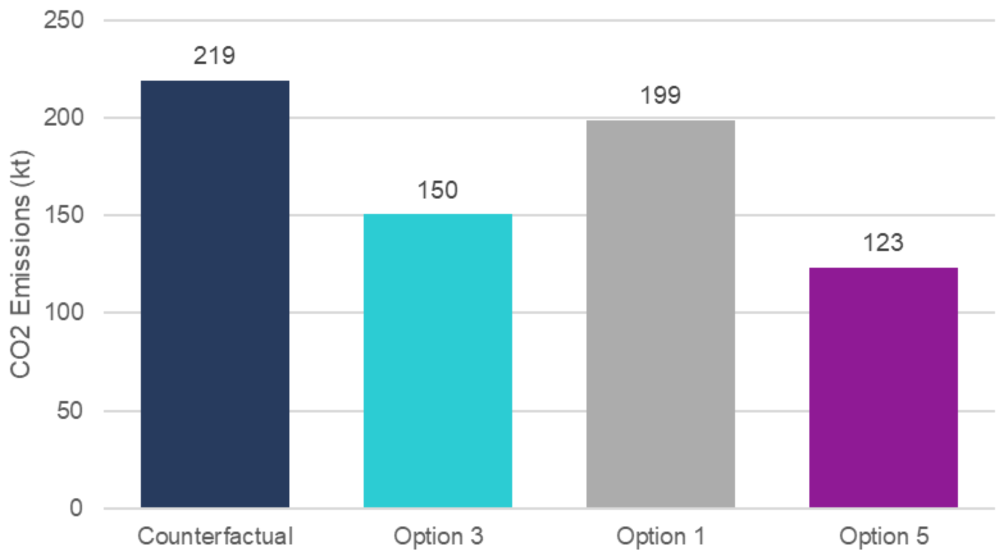
Country costs/benefits – 2030 – sensitivity 5, option 3 vs counterfactual



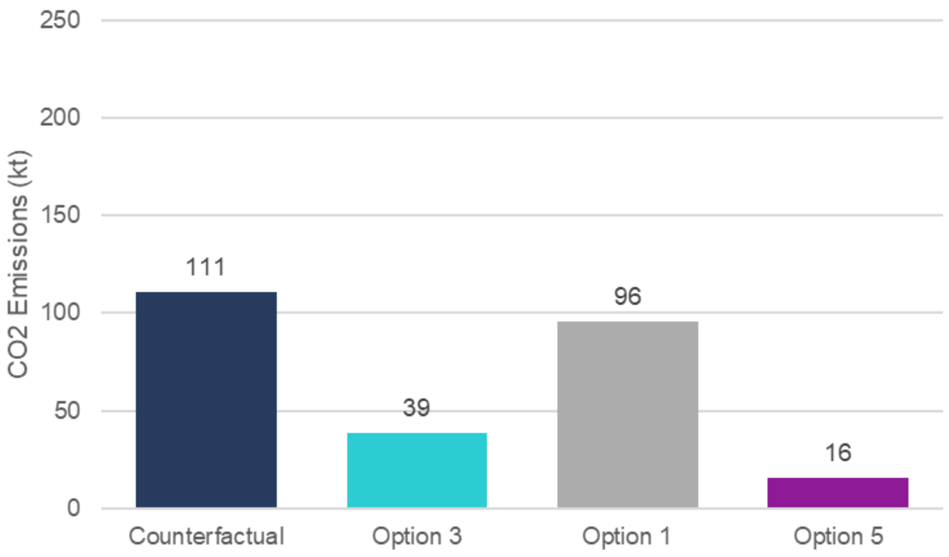
- In option 3, sharing bids between Great Britain, Switzerland and other European countries decrease the French consumer cost (positive consumer surplus) but decrease the surplus for French producers, **resulting in a country benefit of -6M€ for France,** close to that of the base case.
- The **country benefit remains very close between the base case and sensitivity 5 in Great Britain, positive by 8M€ in sensitivity 5,** mainly due to the consumer surplus related to lower activation costs.

In sensitivity 5, reduction in CO2 emissions by options follow the same trend as in the base case

CO2 emissions – Base case - 2030



CO2 emissions – Sensitivity 5 - 2030



- In sensitivity 5, **reduction in CO2 emissions by options follow the same trend as in the base case,** but with lower CO2 emissions for the counterfactual and all options.
- Indeed, in this sensitivity, reduction in price offered by new technologies (Electric Vehicles, Heat Pumps and Power-to-Gas) in upward mFRR and upward RR allows to reduce the use of thermal plants, resulting in lower CO2 emissions.
- **As in the base case, option 5 seems to offer the greatest reduction in CO2 emissions**, but subject to the same limitations in the technical possibility of merging merit orders of two different products.

Note: CO2 emissions for downward reserves are represented in negative because the downward activation corresponds to a decrease in production, thus a reduction in emissions for thermal power plants.

3.6

Modelling and Cost-Benefit Analysis of sensitivities

6. Sensitivity 6 – Share of balancing bids between domestic and cross-border platforms

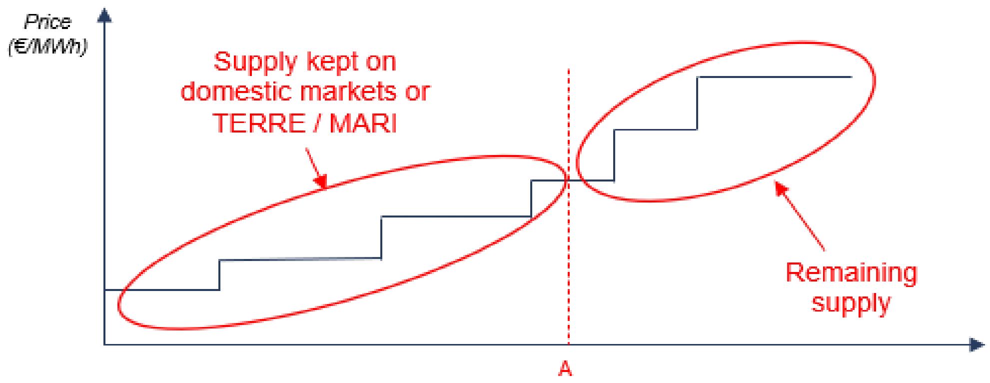
Sensitivity 6 – Description of the sensitivity

Description of the sensitivity:

➢ We consider a different share of balancing bids between domestic and cross-border platforms, placing 10% of bids on the UK CBB platform (rather than 30% in the base case) to represent a very constrained transmission network.

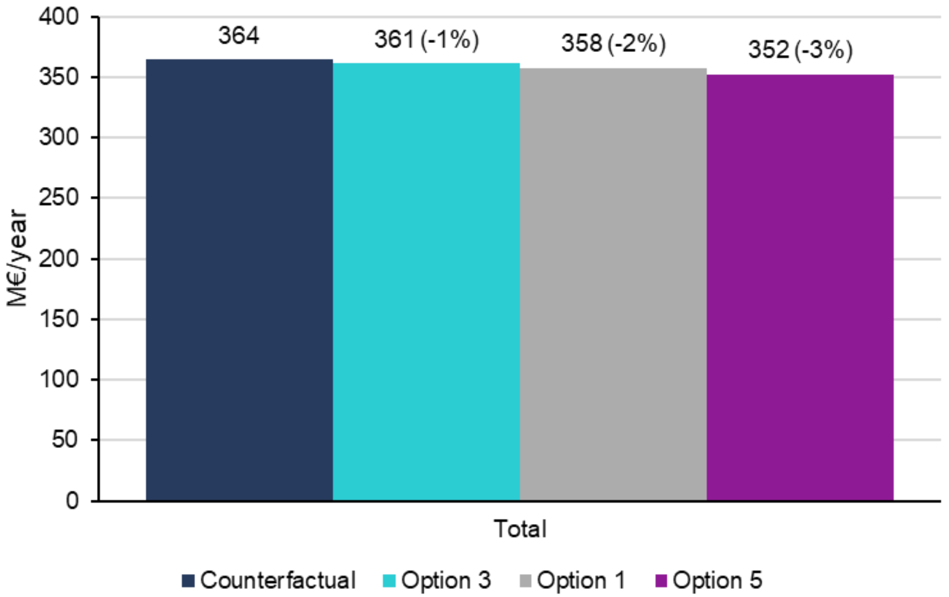
Supply

1. Countries keep the cheapest supply that allows them to cover its demand in 85% of the hours when there is activation.
    - This supply for the UK (and CH) would be placed on their domestic markets.
    - This supply for the other European countries would be placed on MARI or TERRE.
2. For the remaining supply:
    - The remaining supply on the UK (and CH) side would be fully placed on UK CBB market
    - The remaining supply on the other European countries would be split between the 2 CB markets: **10% in UK CBB market in sensitivity 6 (instead of 30% in the base case) and 90% in MARI or TERRE in sensitivity 6 (instead of 70% in the base case).**
    - In addition, under option 5, UK CBB supply for RR and mFRR are merged.

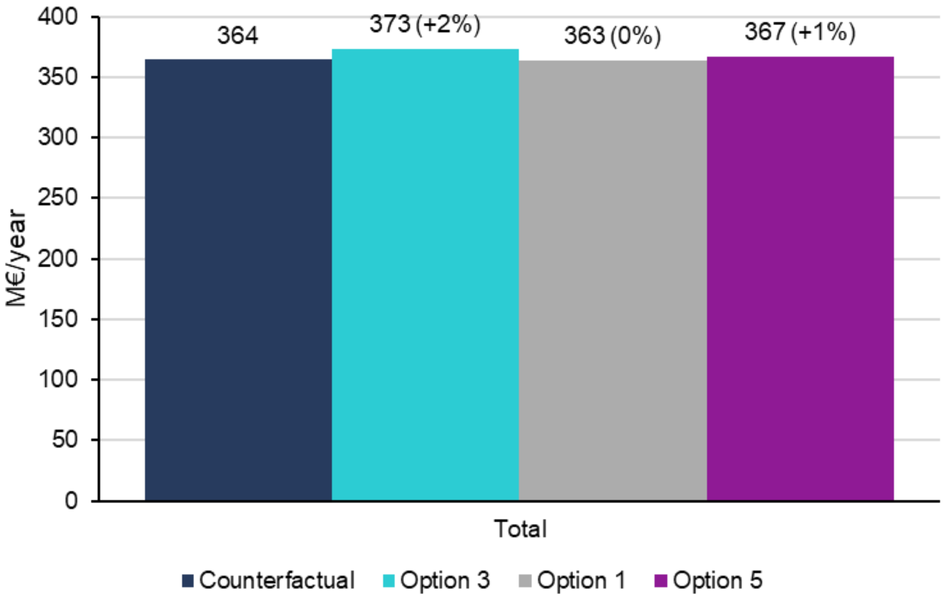


In sensitivity 6, a very constrained transmission network leads to higher activation costs in the different options

Activation cost – Base Case - 2030



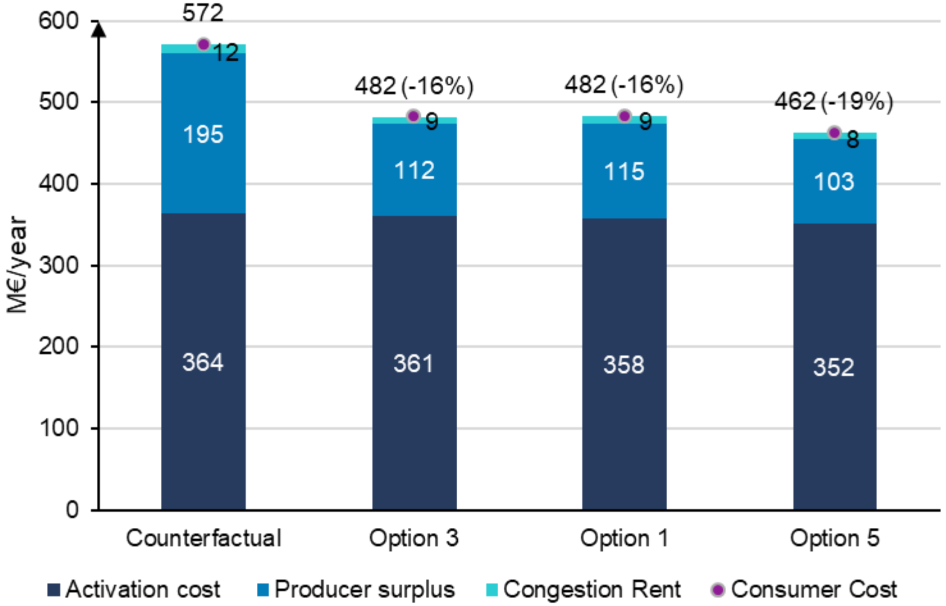
Activation cost – sensitivity 6 - 2030



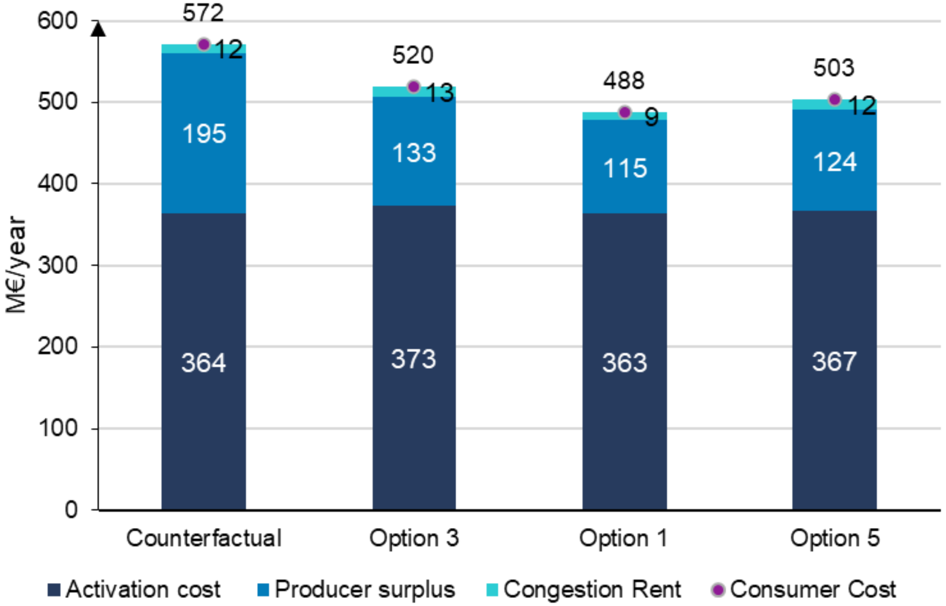
- In sensitivity 6, **a very constrained transmission** means a lower allocation of bids to the UK CBB platform resulting in **higher activation costs in options 1, 3 and 5** than in base case.
- Indeed, the demand placed on the UK CBB platform is assumed to be equivalent to the base case, and assigning too few bids to the UK CBB platform increase activation costs.

In sensitivity 6, a very constrained transmission network also leads to higher producer surplus and congestion rent

Consumer costs split – 2030 – Base Case



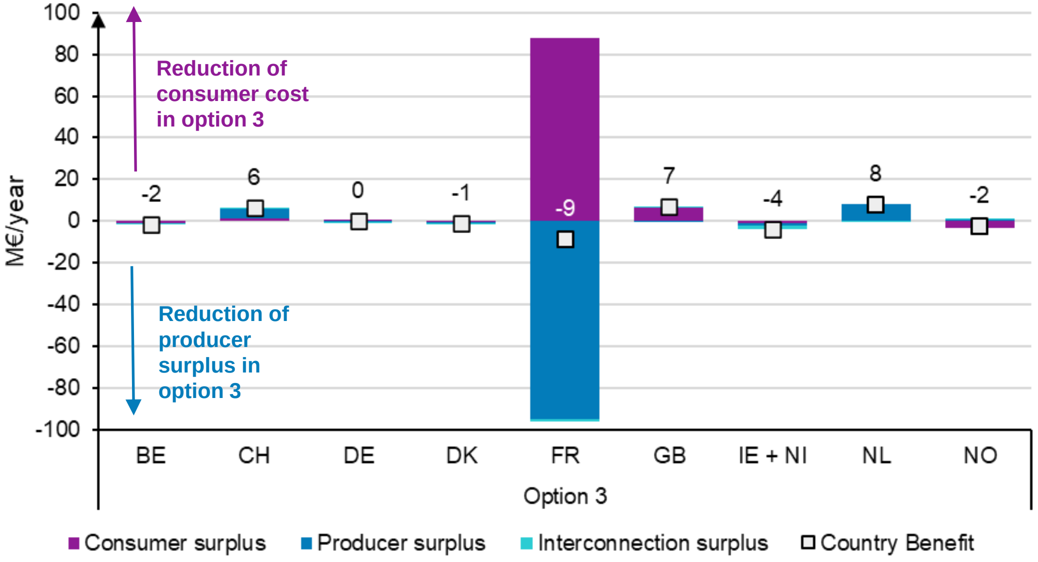
Consumer costs split – 2030 – sensitivity 6



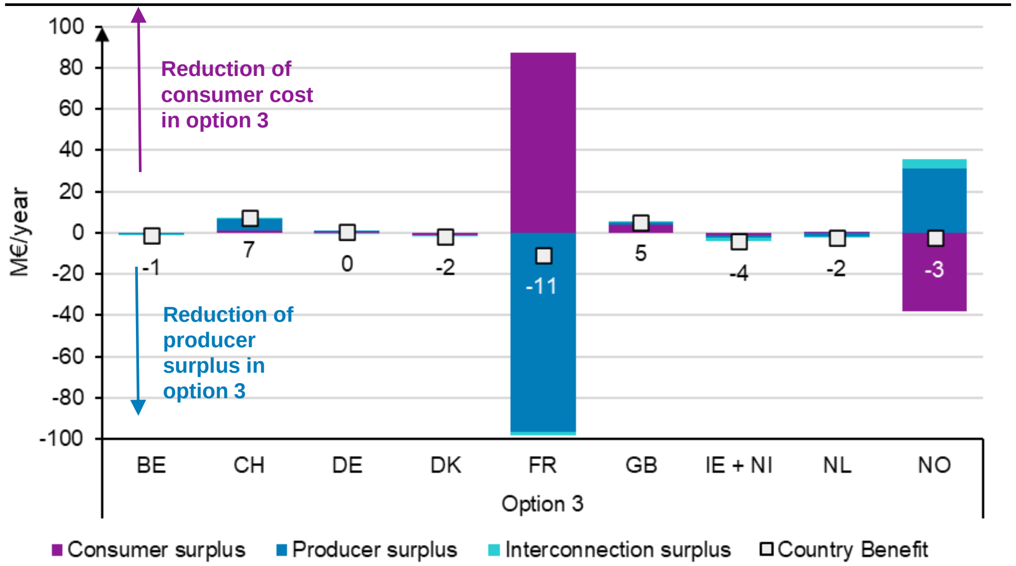
- Similarly to activation costs, **consumer costs are higher in sensitivity 6 than in the base case for options 1, 3 and 5.**
- In addition to the increase in activation costs, the **increase in the producer surplus and the congestion rent** leads to a **significant increase in the consumer cost for options 1, 3 and 5.**
- **Cross-border balancing options lead to a significant reduction** of consumer costs, because of **the rules for allocating demand between UK CBB and TERRE / MARI platforms and to price formation.** As explained previously, the **reduction of demand in EU platforms** (and UK domestic markets) together with the sharing of the less expensive offers lead to a price reduction in the EU platforms, hence applied to large volume. This **reduction in prices in these platforms largely exceeds the similar or slightly higher prices in the UK CBB platform**.

In sensitivity 6, a constrained network leads to quite similar results to the base case for all countries except Norway and in the Netherlands

Country costs/benefits – Base Case, option 3 vs counterfactual



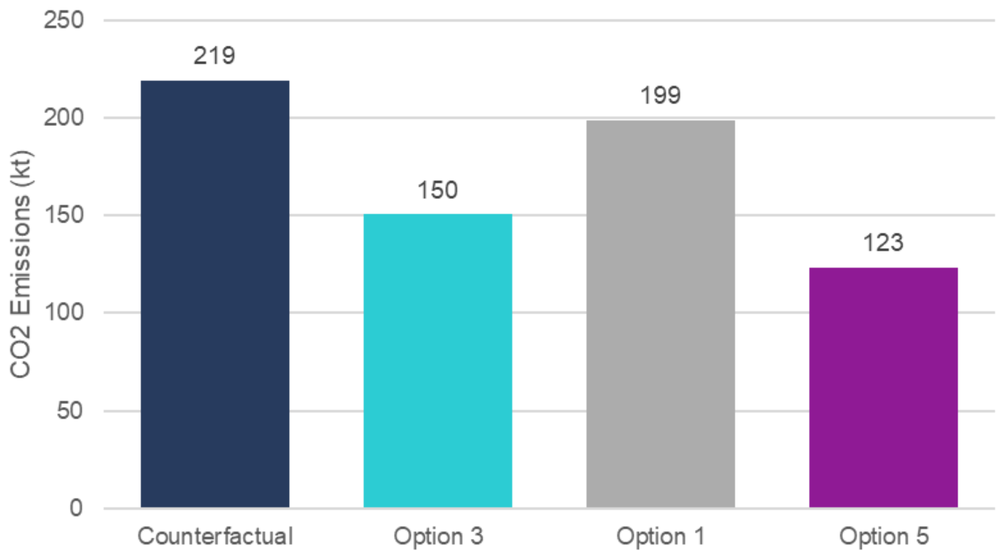
Country costs/benefits – Sensitivity 6, option 3 vs counterfactual



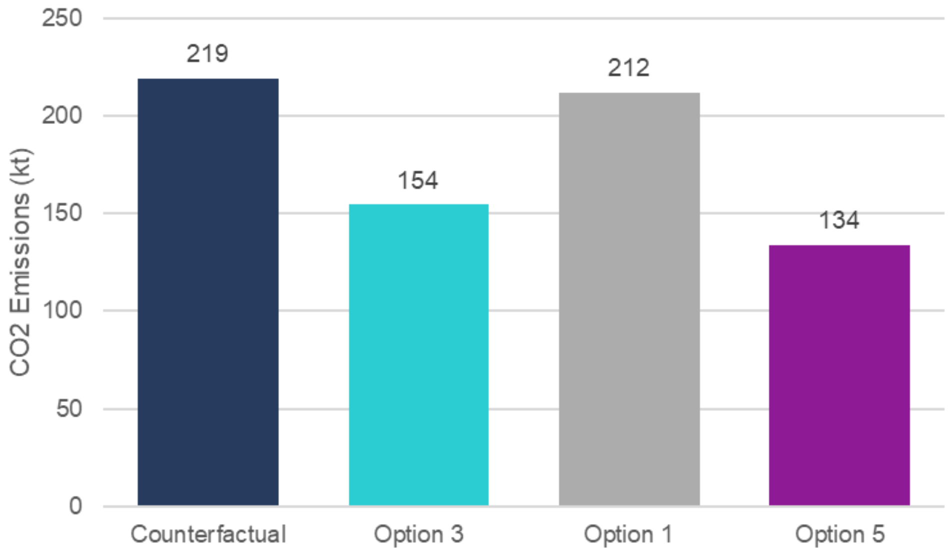
- Compared to the counterfactual, option 3 will lead to a significant consumer surplus in France in sensitivity 6 but conversely will lead to a significant reduction in the producer surplus in France. As a result, the **country benefit in France is negative around -11M€;**
- With this constrained network, there is a **lack of supply to cover Norwegian demand placed on the UK CBB market** leading to periods of **unserved balancing energy**, resulting in a **significant positive producer surplus** and a **significant negative consumer surplus** in Norway.
- The **producer surplus of the Netherlands decreases** with **less possibility to export balancing energy to Great Britain.**
- Despite the constrained transmission network, the **results change little for the UK with a country benefit of 5M€.**

In sensitivity 6, reduction in CO2 emissions by options follow the same trend as in the base case

CO2 emissions – Base case - 2030



CO2 emissions – Sensitivity 6 - 2030



- In sensitivity 6, **reduction in CO2 emissions by options follow the same trend as in the base case,** but with higher CO2 emissions for all options.
- Indeed, in this sensitivity, a very constrained transmission means a lower allocation of bids to the UK CBB platform, e.g. limiting the exchange of hydro, replaced by thermal power plants, resulting in increased CO2 emissions.
- **As in the base case, option 5 seems to offer the greatest reduction in CO2 emissions**, but subject to the same limitations in the technical possibility of merging merit orders of two different products.

Note: CO2 emissions for downward reserves are represented in negative because the downward activation corresponds to a decrease in production, thus a reduction in emissions for thermal power plants.

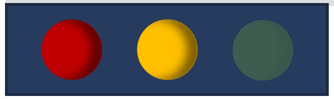
4.

Multicriteria assessment and recommendations

Option 1: UK Platform before TERRE/MARI

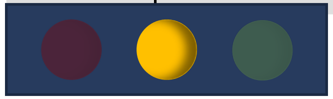
Economic efficiency

- Economic welfare of about 6M€/year, consistent through all sensitivities
- Interactions with intraday market and cross-zonal gate closure
- Enables resources with longer activation times to participate, but to the detriment of Intraday market



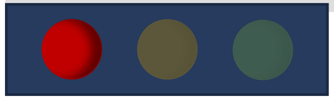
Security of supply

- Risk of higher imbalances due to earlier ID GCT, but higher balancing resources
- Limited impact on existing markets, so should not prevent SOs to find necessary resources.
- Having the UK CBB market beforehand limits the risk of unserved in RR since the unmet demand on the UK CBB can be placed on TERRE or the domestic market.



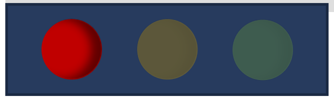
Operational complexity

- No/limited operational impact on EU platforms.
- Requires the definition of intermediate markets in terms of timeframe with product specification. This would require to delay ID and IC GTC, leading to numerous operational changes.



Acceptability

- For UK RR, this would require to push at least by 15 minutes the ID GCT. IC GCT should also be delayed.
- For UK mFRR, there could be an interaction with TERRE deadlines.
- Local framework may require BSPs to provide all capacity in EU or local platforms.



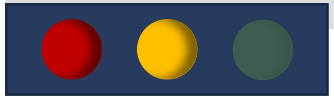
- **The timelines of this solution are key to enable its potential.**
- **In order to limit the overlapping of the different markets, the timing for submissions and results could be reduced.**
- **However, the current deadlines are not compatible with this option.**

* Compared to participation in EU platforms

Option 2: Parallel markets – BSP choice

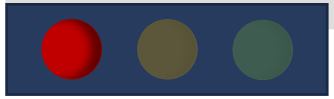
Economic efficiency

- BSPs choices may not follow an optimal dispatch as they submit bids with imperfect information, e.g. some bids can be refused from the chosen market and would have been accepted in the other market.
- Risk of lack of liquidity with the possibility for BSP to avoid the platform because of IC uncertainty.



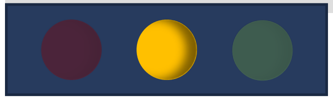
Security of supply

- BSPs have limited information on interconnection availability and market liquidity.
- Could cause security of supply issues, as it could split liquidity/ reduce accessible resources and as TSOs would have limited time to satisfy the need differently.



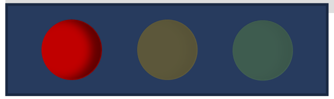
Operational complexity

- Limited impact on existing markets. SO have a say on BSP offers in a constrained timeline.
- The different markets already exist, the aim of this option is to enable stakeholders in UK and in EU to access all relevant markets.
- May need to provide access to IC capacity to BSPs closer to real time.



Acceptability

- Local framework may require BSPs to provide all capacity in EU or local platforms. E.g. UK BSPs can only participate in the UK market.
- The lack of control on resources allocation may be a barrier for TSOs.



- **The split of liquidity could reduce the efficiency of such an approach, and raise concerns in terms of access to adequate resources.**

Note: a combination of options 2 and 3 could be envisaged to encompass countries using a given type of reserves and those who don't

Option 3: Parallel markets – TSO allocation

Economic efficiency

- Economic welfare of about 3M€/year, but net benefits are negative in certain sensitivities.
- The proportion of the needs and the bids put in the platform is a key choice for TSOs. It may not follow an optimal dispatch but TSOs have information their national bids and could exchange information to improve the dispatch, at least compared to option 2.

Security of supply

- Could cause security of supply issues, as it could split liquidity/ reduce accessible resources and as SOs would have limited time to satisfy the need differently.
- More limited compared to option 2 as SOs have control.

Operational complexity

- The different markets already exist, the aim of this option is to enable stakeholders in UK and in EU to access all relevant markets.
- The timelines would be constrained for TSO to exchange information and allocate bids.

Acceptability

- Potentially contradictory to obligation to bid in EU platforms.
- If there is no national market (e.g. RR in Germany), TSOs have no bids to allocate.
- The TSOs will have to agree on the allocation rules. Risk of being too conservative.

- **The definition of transparent allocation rules is key to ensure the viability of the mechanism.**
- **Country-by-country agreements could facilitate the implementation process.**

Option 4: Indirect participation in EU platform

Economic efficiency

- The efficiency of the mechanism primarily depends on ESO access to information.
- If IC constraints are low, this solution could enable UK bids and needs to access the EU platform benefiting both UK and EU. Otherwise, possibility for NGESO to avoid the platform because of SoS issues
- Choice of bidding zone to participate in.

Security of supply

- Limited impact on existing markets, so should not prevent SOs to find necessary resources.
- Unlikely to provide significant additional resources.

Operational complexity

- The dispatching of the UK position across the connected countries may be complicated. For MARI this implies the allocation of bids across at least 5 countries. Less complex for TERRE (only France and Ireland).

Acceptability

- The compatibility of a UK “fictive” BSP to EU regulation in question.
- How to ensure reciprocity?
- Some TSOs may want to limit the capacity of ESO to impact EU prices.

- **Efficiency highly depends on ability of the ESO to allocate bids/offers in adequate bidding zones.**
- **Reciprocity and legality could be questioned.**

Option 5: TSO directly nominate IC

Economic efficiency

- Economic welfare of about 12M€/year (higher range of benefits). It widely depends on the ability of TSOs to merge mFRR and RR demands and bids in the UK CBB platform.
- Merging mFRR and RR may modify market signal.
- Could enable resources with longer activation times to participate.

Security of supply

- Limited impact on existing markets, so should not prevent SOs to find necessary resources.
- Unlikely to provide significant additional resources.

Operational complexity

- Limited operational impact on EU platforms.
- Requires the definition of intermediate timelines for information sharing, balancing request and approval.
- Requires the implementation of a new process between the SOs.

Acceptability

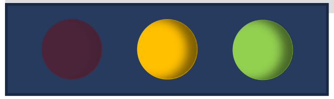
- Cooperation could be done country-by-country.
- Some SOs may want to limit the capacity of ESO to impact EU prices.
- Acceptability of EU institutions?

- **The key issue with this option is the capacity of TSOs to exchange information on their needs and availabilities in constrained timelines.**
- **The benefits could be minored by the uncertainty on the ability to rebalance on shorter timeframes.**

Option 6: “Volume-coupling”

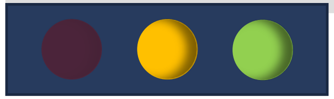
Economic efficiency

- The efficiency of the mechanism primarily depends on the number of cooperating countries.
- With all TERRE/MARI members participating, the economic efficiency would be close to optimum, but wouldn’t enable new resources.
- Limited impact on existing markets



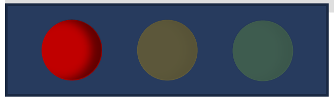
Security of supply

- Likely to increase accessible resources.
- Wrong initial coupling could lead to inefficient flows, limiting accessible resources.



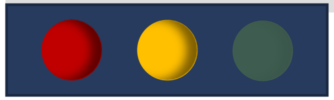
Operational complexity

- The timelines of the balancing markets are reduced in order to be as close as possible to real time while enabling sufficient time for the global process.
- Adding an additional process in these timelines would require trade-off.



Acceptability

- In the spirit of the TCA as regards day-ahead markets.
- Data restrictions similar to LVC (TCA annex 4) could apply to cross-border balancing.
- Cooperation with a considerable number of countries is required for the mechanism to be efficient.



The main barriers for this option are:

- **the cooperation of other countries (data exchange, access to TERRE/MARI algorithms, agreement to change inputs) ;**
- **the timelines to exchange information, obtain results and share results are constrained. The TERRE/MARI timelines could be adapted.**

Modelling has resulted in lower economic welfare for parallel markets than expected, other options seem more favourable

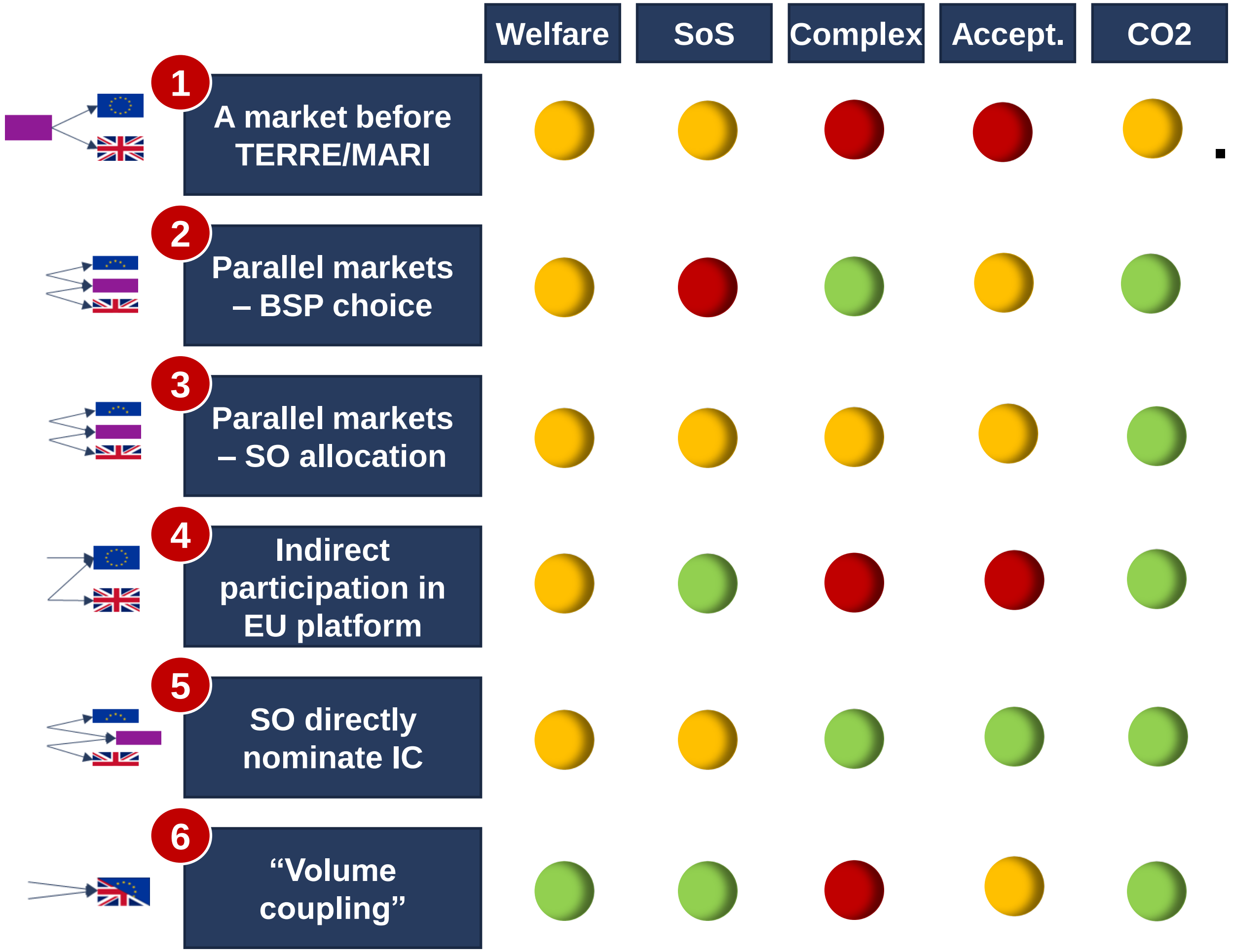
	Economic welfare	Market signal	Liquidity & Competition	Economic Efficiency
1 A market before TERRE/MARI	**About 6M€/year** Results are consistent through sensitivities but impact on ID	Interactions with intraday market and cross-zonal gate closure	Particip. of longer activation times resources, but to the detriment of ID	
2 Parallel markets – BSP choice	**Likely below option 3** Benefits below option 3 as SO have more information	Limited impact on existing markets	Possibility for BSP to avoid the platform because of IC uncertainty.	
3 Parallel markets – SO allocation	**About 3M€/year** Net benefits are negative in certain sensitivities	Limited impact on existing markets	Possibility for SO to avoid the platform because of SoS issues.	
4 Indirect participation in EU platform	**Likely close to Option 3** depends on implementation / NGESO decisions	Limited impact on existing markets	Possibility for NGESO to avoid the platform because of SoS issues	
5 SO directly nominate IC	**Below 12M€/year** Higher range of benefits, but likely lower in practice.	Merging mFRR and RR may modify market signal	Potentially combines mFRR and RR, broadening the pool of resources.	
6 "Volume coupling"	**Likely close to optimum** but strongly depending on implementation	Limited impact on existing markets	Economic efficiency could be close to optimum	

Options 3 and 5 appear to be the most adequate in terms of SoS, complexity and acceptability

Option	Security of supply	Operational complexity	Acceptability	Energy Transition*
1 A market before TERRE/MARI	Risk of higher imbalances due to earlier ID GCT, but higher balancing resources	Delay ID and IC GCT, leading to numerous operational changes	Delay ID and IC GCT, leading to numerous changes in UK and in EU	**About 15 kt/year** Net benefits are negative in certain sensitivities
2 Parallel markets – BSP choice	Could cause security of supply issues, as it could split liquidity/ reduce resources	Limited impact on existing markets. SO have a say on BSP offers in a constr. timeline.	Local framework may require BSPs to provide all capacity in EU or local platforms	**Likely below option 3** Benefits below option 3 as SO have more information
3 Parallel markets – SO allocation	Could cause security of supply issues, but more limited than option 2 as SO have control	Limited impact on existing markets Constrained timelines for SO	Local framework may require SOs to provide all capacity in EU or local platforms	**About 75 kt/year** Results are consistent through sensitivities
4 Indirect participation in EU platform	Limited impact on existing markets, should not prevent SOs to find resources	The dispatching of the UK position across the connected countries may be complicated	Compatibility of UK “fictive” BSP to EU regulation in question – Reciprocity?	**Likely close to Option 3** depends on implementat. / NGESO decisions
5 SO directly nominate IC	Limited impact on existing markets, should not prevent SOs to find resources	Limited operational impact on EU platforms, but requires a new process between SOs	Cooperation could be done country-by-country	**Below 85 kt/year** We modelled the higher range of benefits.
6 “Volume coupling”	Likely to increase accessible resources, conditionally to efficient implementation.	Adding additional processes in tight timelines may require trade-offs	Data restrictions similar to LVC could apply	**Likely close to optimum** but strongly depending on implementation

Note: ID = Intraday, IC InterConnector, GCT = Gate Closure Time, SO = System Operator, LVC = Loose Volume Coupling

The different options imply a trade-off between welfare and complexity



Option 6 - “Volume Coupling” would likely provide the highest welfare – close to a full participation of UK to EU platforms – and increase security of supply, although its **operational complexity could be a barrier to its implementation**.

- On the other hand, other options would likely provide modest benefits, which will also greatly depend on how bids/offers will be split between domestic markets and the UK-EU CBB platform.
  - Option 1 would involve a limited number of countries, but may provide benefits. **The main obstacle of this option is the operational implications**, as the ID GCT would need to be anticipated. This could be complex, detrimental to the overall efficiency of the market and unacceptable to many stakeholders, including TSOs.
  - Options 2 and 3 **would require lower complexity, but our modelling has shown limited economic benefits** – about 3M€/year and could even be negative. These benefits would be highly subject to the learning process of TSOs (and BSPs in option 2), which may desert the CBB or on the contrary optimise and coordinate their participation to improve results. The legal possibility of sharing bids for EU parties would have to be confirmed as it seems contradictory to EU regulation. Finally, option 2 leads to a loss of visibility and control on available resources, which could affect security of supply.
  - **The benefits of option 4 are difficult to capture** as it depends on the ability to split net demand and offer amongst the different interconnectors. Moreover, beyond its complexity, **this option is likely to face legal barriers to the participation of a UK representative party in EU platforms and lack of acceptability** as it could be perceived as asymmetric and non reciprocal.
  - **Option 5 appears as a pragmatic approach** although its actual benefits depend on the actual use of the CBB platform by the TSOs. The modelling results are **likely overestimating the benefits** for a given participation strategy as it does not fully reflect the technical characteristics and needs. This may **lead to a situation of low benefits compared to high implementation costs**.

Key takeaways

1. All the options analysed present some drawbacks and/or **operational difficulties** and the **modelling of these options is complex** as it **strongly depends on how these options will be operationally used by the SOs** and to what extent they will share their supply and demands.

2. **The most promising options seem to be option 5** where TSOs voluntarily share balancing bids and offers and can request activations on an ad hoc basis and **possibly option 3** with parallel markets and where TSOs allocate supply and demand between the domestic/EU platforms and the UK CBB platforms.

3. Option 1 (a market before TERRE/MARI), option 4 (indirect participation in EU platform) and option 6 (Volume coupling) **present very significant complexities and depend heavily on the willingness of TSOs to engage in this integration work.**