European Resource Adequacy Assessment

2025 Edition

ENTSO-E's proposal for ACER's approval

Annex 5 – Proof of Concept: Application of Revenue-Based EVA Approach on European Scale

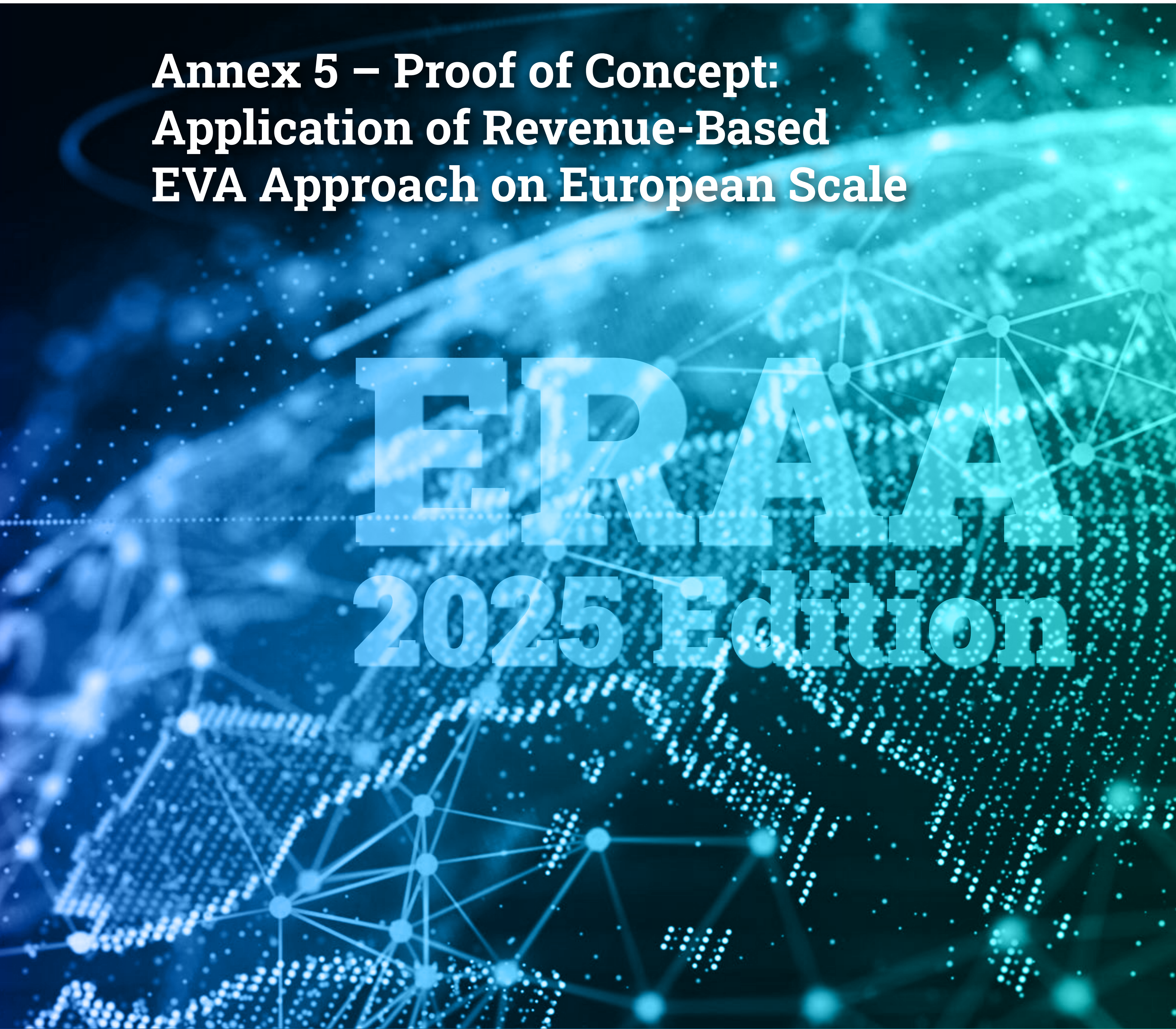

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Table of Contents

1 Introduction

In parallel to the central reference scenario assessment using the cost-based economic viability assessment (EVA) approach presented in detail in Annexes 2 and 3, the European Resource Adequacy Assessment (ERAA) 2025 includes the refinement of the alternative revenue-based EVA approach, in compliance with the ERAA Methodology[1]. This approach, already applied in several national resource adequacy assessments, aims to observe viability assessment as a direct comparative study of unit-level (or group-level) revenues and costs rather than as an evaluation of the system's cost-optimal state. This methodology has been first developed and tested in the context of ERAA 2024 modelling and has been further consolidated in ERAA 2025 with the objective of being applicable for the EVA in future ERAA editions.

A proof-of-concept study of a revenue-based EVA was initiated following the first case study in ERAA 2024. It now confirms the maturity of this methodology for application in the next ERAA cycle. This method differs from the currently applied EVA approach in ERAA, which focuses on the global minimisation of overall system costs[2]. Although the two approaches theoretically converge under a specific set of conditions and assumptions, in a system as wide and complex as European one, they can yield to substantially different net results both from the overall system perspective and at study zone level. The revenue-based approach aims to evaluate the performance of each (or groups of) unit on the electricity-only market to estimate its profitability (i.e. economic viability) in the modelled conditions. Units that are not economically viable are at risk of decommissioning. Similarly, profitable investment candidates indicate potential for expansion.

This annex presents global insights on the revenue-based EVA, outlining two different implementations (A and B), and presents a proof of concept for each implementation approach.

The goal of implementing revenue-based EVA is to enhance the understanding of EVA decisions. This year's proof of concept aims at validating the two implementations to support the transition to applying revenue-based EVA in upcoming ERAAs.

[1] ACER (2020).

[2] See Annex 2.

2 Methodology

2.1 Missing money analysis

Unit profitability is assessed through missing money analysis, an iterative process that aims to identify system equilibrium. Each iteration is composed of the following steps:

1. Simulating economic dispatch (ED)
2. Calculating the net revenues earned by each unit by subtracting short-run marginal costs from electricity market revenues
3. Computing the earnings before interest, taxes, depreciation, and amortisation (EBITDA) of each unit by deducting annual fixed costs from its yearly net revenues[3]
4. Calculating the unitary profitability (k€/MW/yr) for each unit by dividing the EBITDA (k€/yr) by its capacity (MW).
5. Ranking all units based on their per-unit profitability.
6. Among units with negative profitability (EBITDA < 0), removing those with the largest shortfall from the system in the next market simulation. In Implementation B, capacities where EBITDA exceeds capital expenditures (CAPEX)[4] can be expanded. If at least one capacity satisfies this condition, the most viable one is selected for expansion. The decommissioned and commissioned capacity is calculated for each study zone, decreasing as iterations progress. Through this process, analysis becomes increasingly precise. This *gradient descent* explains the theoretical convergence with the optimisation protocol.

The merit order and overall prices in the system will change due to global system evolution. Hence, units that were slightly missing money may become viable, while others may become unviable. The process ends when all the units remaining in the system are profitable (EBITDA > 0). Figure 1 graphically represents the logic described above.

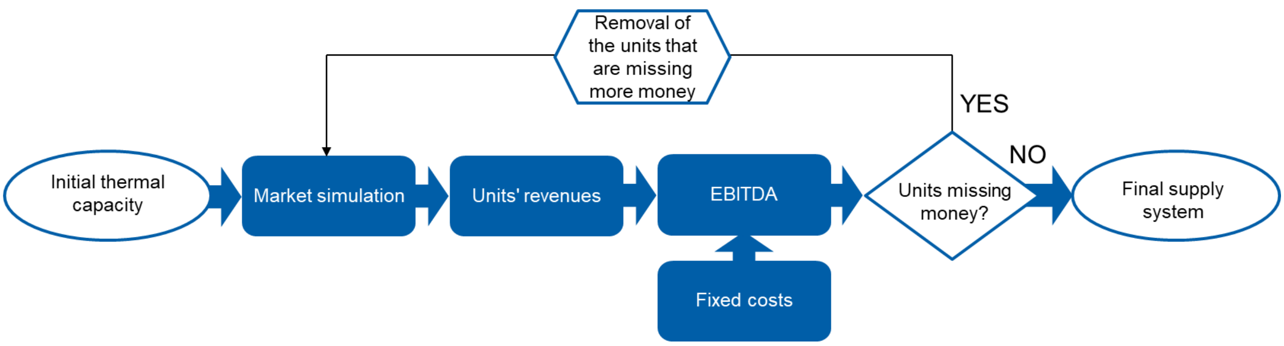


Figure 1: Iterative process of the missing money analysis

[3] Taking into account risk aversion.
[4] Taking into account risk aversion.

2.2 New entry simulation

2.2.1 Implementation A

To assess the feasibility of investing in new capacity, investment candidates are added to the original system state (i.e. National Trends data “pre-EVA”) until the expansion potential of each study zone is exhausted. This results in a system that includes both existing and all additional potential capacity. This system undergoes a missing money analysis, where, with each iteration, the direct competition between existing and expansion candidate units is observed. When computing the EBITDA of the latter units, net revenues are reduced by the annualised costs described in Section 10.11 of Annex 2, taking into account investor risk aversion. This allows for the combined assessment of the profitability of both existing and potential capacity, identifying the missing-money units from both categories to be removed from the system.

Once the iterative process concludes, the resulting system capacity consists of a mix of existing units and investment candidates, with the latter representing new entries. All the remaining units are economically viable.

2.2.2 Implementation B

In Implementation B, the starting point of the system is the generation fleet of the National Trends scenario. Then, investment candidates (up to expansion potential) are assessed incrementally until investment candidates become not viable. Also, in each iterative step the economic viability of existing units is simultaneously assessed, thus multiple and competitive entry and exit decisions for market capacity are considered.

2.3 Multiyear analysis

2.3.1 Implementation A

The scope of ERAA 2024 covers the time horizon (TH) from 2028 to 2035. The target years (TYs) explicitly modelled within this period are 2028, 2030, 2033, and 2035. Decisions regarding the expansion or decommissioning of capacity in a given TY consider the economic performance of that capacity in the subsequent years of the TH, reflecting the perspective of a rational investor. Therefore, while assessing one TY, the following years are also simulated. The process for each TY is described below:

1. An iterative simultaneous missing money analysis is conducted for all TYs between the “decision year” currently assessed and the end of the TH.
2. Once all the iterative processes reach their convergence, e.g. meaning all units are profitable (i.e. economically viable), the net present value (NPV) of the profitability of each unit is calculated by actualising the EBITDA obtained in each TY to the current year.
3. Decisions on the system’s evolution are made as follows:
    - Existing units with negative EBITDA in the last iteration of the current TY and negative NPV are decommissioned and removed from the system.
    - Investment candidates with positive EBITDA in the last iteration of the current TY and positive NPV remain in the system and are considered new entries. In all other cases

when the EBITDA and the NPV of a unit have opposing signs, no decision is made, and the unit remains provisionally in the system and is assessed further in the following TY.

4. The resulting system is then analysed in the next TY of the TH.

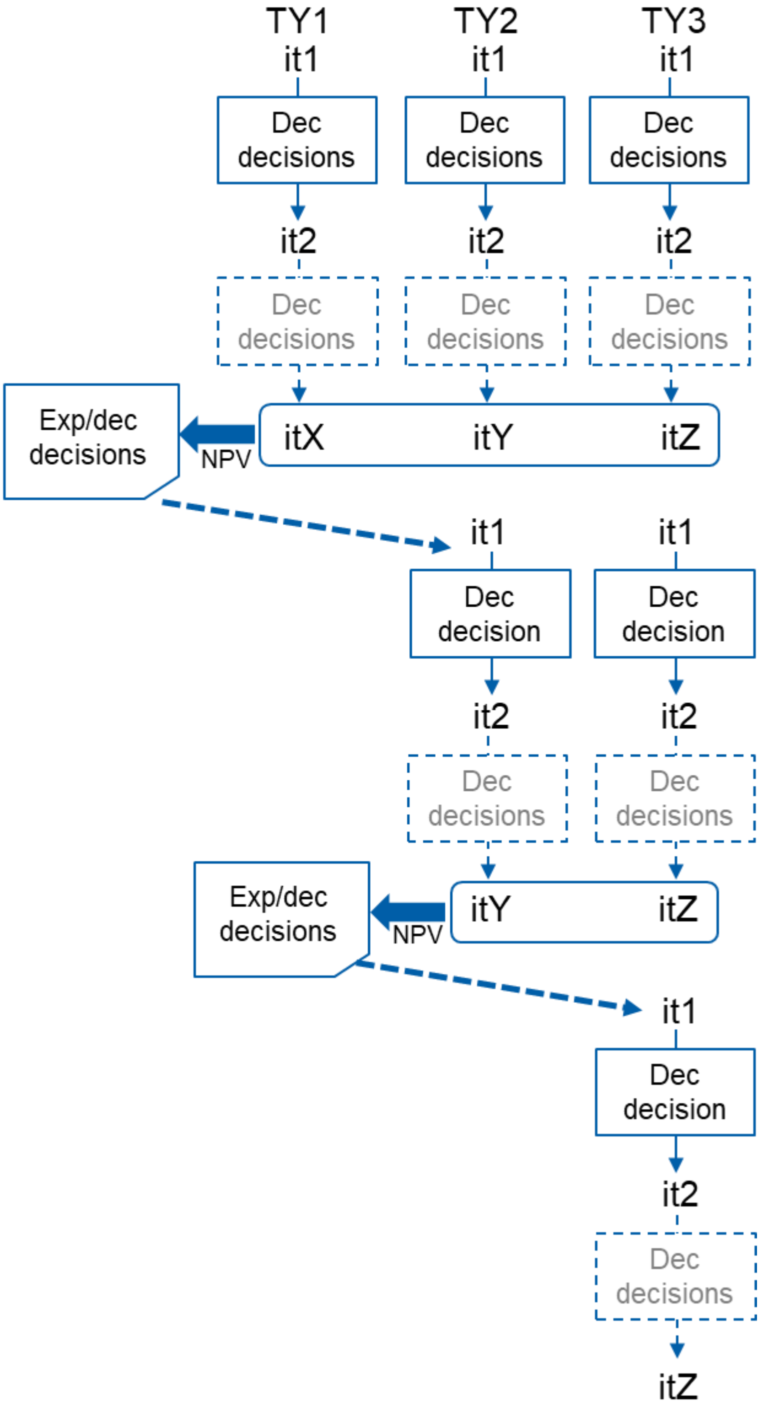


Figure 2: Multiyear analysis of Implementation A

This logic for the representation of investors' decision-making assumes very high foresight over the TYs that allows for investments with high probability of ultimately proving profitable.

2.3.2 Implementation B

Implementation B starts from an economic dispatch run of each target year, 2028 to 2035, based on the National Trends scenario. The economic state of the capacity subject to EVA for each TY is then assessed, and computed via the NPV value :

- $NPV = \sum_{yrs}(1 + HR)^i \,(Rev - FOM - CAPEX_{annuity})$ for new units
- $NPV = \sum_{yrs}(1 + HR)^i \,(Rev - FOM)$ for existing units

Then, for each study zone modelled, entry and exit decisions of capacity are assessed:

- If a decommissioning candidate (i.e. existing capacity) is missing money (NPV <0) is not profitable in the current (i.e. the first) decision TY, then the most unviable decommissioning candidate(s) (lowest NPV per MW) is decommissioned. The volume of each decommissioning step per study zone is variable, starting from 500MW, rounded downwards to fit an integer number of units.
- Reciprocally, if a commissioning candidate appears to be profitable (NPV > 0) in the current TY, then the most viable commissioning candidate(s) (highest NPV per MW) is commissioned in the system. The volume of commissioning step per each study zone is variable, starting from 500 MW, rounded downwards to fit an integer number of units.

Once decisions have been made for all study zones, economic dispatch with the refreshed generation is run, and the process is iterated until viability is achieved for all study zones (no capacity is extra profitable to justify additional capacity expansion; no capacity is unviable and should be removed).

The process is then repeated for the next decision TY (assessing a new NPV estimate from such decision TY till the end of the TH), as depicted in Figure 3.

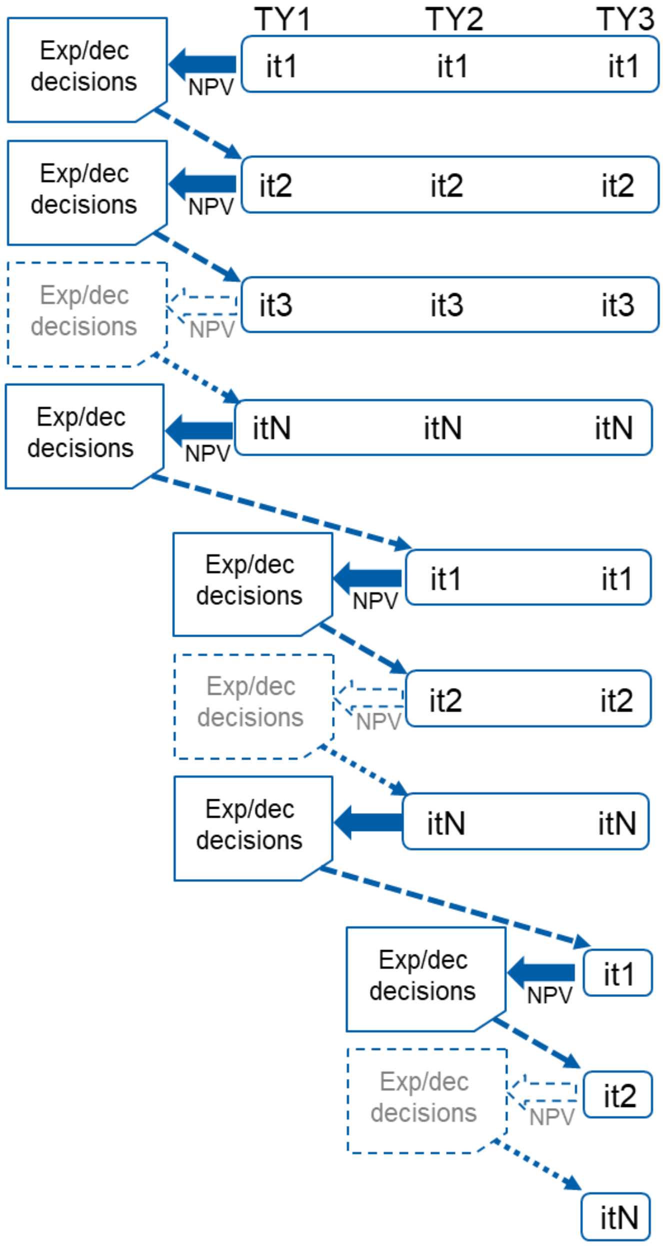


Figure 3: Multiyear analysis of Implementation B

This logic for the representation of investor decision-making process assumes a myopic level of foresight on entry and exit decisions over the future TYs, with respect to each individual TY assessed. It means that irrevocable decisions on investments and decommissionings are met based on the outcomes of each decision TY under consideration. This entails the observation of "regretted capacity" in the final status of the system: capacity that appeared viable from the analysis of a specific TY may become unprofitable later on due to different economic conditions in future TYs which were not foreseeable by the rational investors when making the decision in the past and now constitute "sunk costs".

2.4 Non-consecutive target years

The ERAA 2025 collected data for four non-consecutive TYs: 2028, 2030, 2033, and 2035. However, the EVA is an integrated model over multiple years, spanning 2028–2035.

To overcome this issue, data for non-TYs are obtained as follows:

- In Implementation A: By interpolating the corresponding values of the previous and following TYs. For example, the EBITDA of a unit in the non-TY 2029 is computed by interpolating the EBITDA of that unit in TYs 2028 and 2030.
- In Implementation B: By repeating the previous results. For example, the EBITDA of a unit in the non-TY 2029 is taken as that of TY 2028.

These approaches help preventing a discontinuity in the evolution of the units' economic performance over the TH, which could lead to unrealistic commissioning or decommissioning decisions.

2.5 Years following the last TY

The EVA needs to consider that the viability of unit is also impacted by the economic performance after the last TY of the TH, also referred to as "remaining economic lifetime" of the capacity assessed. To model this aspect, it is assumed as a proxy that the last TY of the TH is the most representative of the farther future and thus the realised EBITDA is repeated in the following years. Of course, the further ahead this repetition occurs, the smaller its contribution to the NPV due to time depreciation of future cash flows.

This approach maximises the use of the known input data and results from the simulation of the last TY in the available TH.

2.6 Mothballing simulation

Some units are eligible to mothballing. This means that if a unit would be decommissioned due to economic non-viability in a given year, it can instead only temporarily exit the market and return at a later TY when economic conditions are favourable again.

To account for this decision opportunity, in Implementation A, when a unit is considered for mothballing, the economic performance of this option is assessed. This prescribes the inclusion of mothballing costs when calculating the NPV, such as the cost associated with entering mothballing, the lower fixed operation and maintenance costs during the mothballed period, and finally the costs for exiting mothballing. If the NPV is positive, it indicates that mothballing and a later return to the market is economically beneficial. If the NPV remains negative, the unit is deemed unprofitable and the decommissioning decision is permanently confirmed.

Mothballing options are still being developed for future inclusion in the Implementation B.

2.7 Life extension simulation

Some units expected to be decommissioned, for aging (or other) reasons are eligible for lifetime extension. This means that if a unit is profitable enough to cover the life extension cost at the time of decommissioning, it can remain in the market for a specified number of additional years. This allows the unit's capacity to be preserved during these years at a cost lower than that of a new entry.

The possibility of lifetime extension is granted by keeping respective units in the market in the simulation of the first TY following their expected decommissioning date. In addition to confirming their profitability in that year, the NPV including the lifetime extension costs, is also assessed. If the NPV is positive, the unit remains profitable in the coming years and is not decommissioned. However, in case of a negative NPV extending the lifetime of the unit is not economically viable.

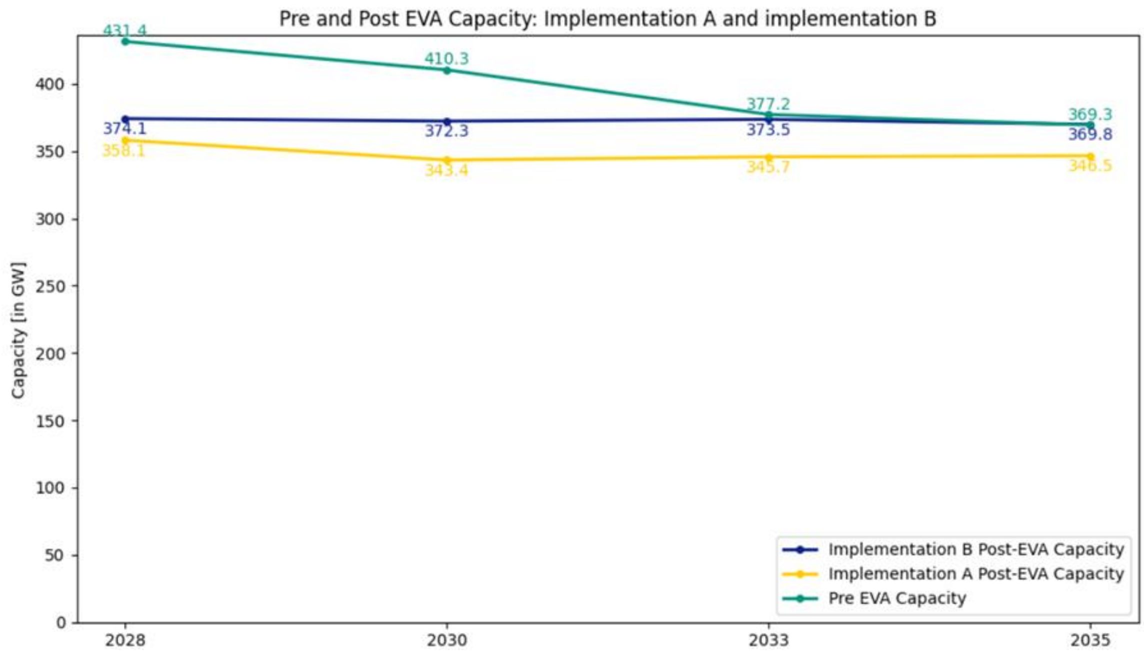
2.8 Different implementations

Error! Reference source not found. describes the main technical differences between Implementations A and B.

Table 1: Overview of differences between EVA approaches and implementations

Feature	Revenue-based EVA		Cost-based EVA	Expected impact on results
	Implementation A	Implementation B		
Unit clustering	Single units	Clustered units	Clustered units	Minor
Decision protocol	Investment potential is saturated, then only decommissioning decisions are made iteratively.	One commissioning and decommissioning decision is made in every iteration.	Capacity is adjusted to minimize the overall system costs	Option B may see more replacement of least viable capacities (coal, lignite) with new ones.
Perpetuity	Implicit modelling to 2045 through repetition of 2035	Implicit modelling to 2045 through repetition of 2035	Repetition of investment costs to the economic lifetime and operation costs to	Revenue based EVA implementation mitigates impact of the last TY perpetuity
Reserves	Volume provision	Dedicated percentage of capacities	Volume provision	Undefined
Flow-based modelling	NORDIC and CORE Flow Based	NORDIC and simplified CORE Flow Based	NORDIC and simplified CORE Flow Based	A more granular Flow Based implementation allows for a more detailed representation of network constraints on simultaneous cross-border exchanges.
Mothballing	Yes	No	Yes	Option B might make decommissioning decisions in case where the other options would decide for mothballing. Negligible considering low volume of mothballed capacities.

3 Revenue-based EVA approach results



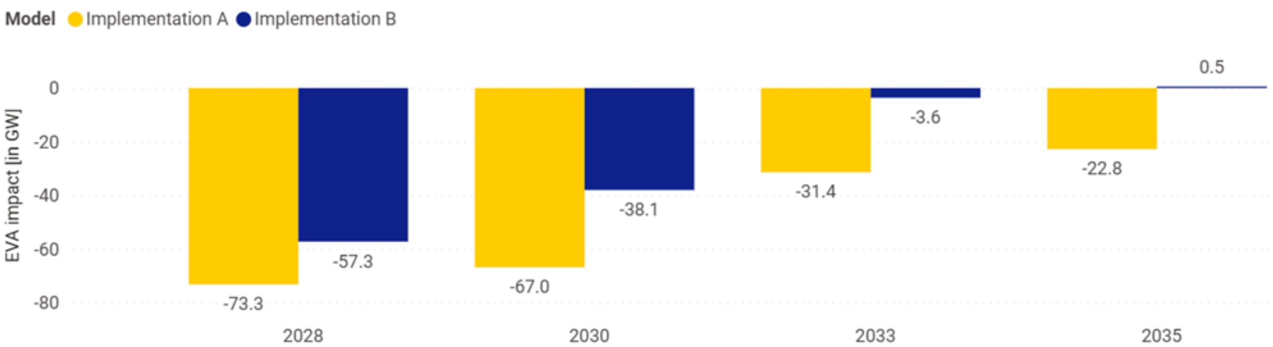


Figure 4: Case study result overview – pan-European

3.1 Implementation A results

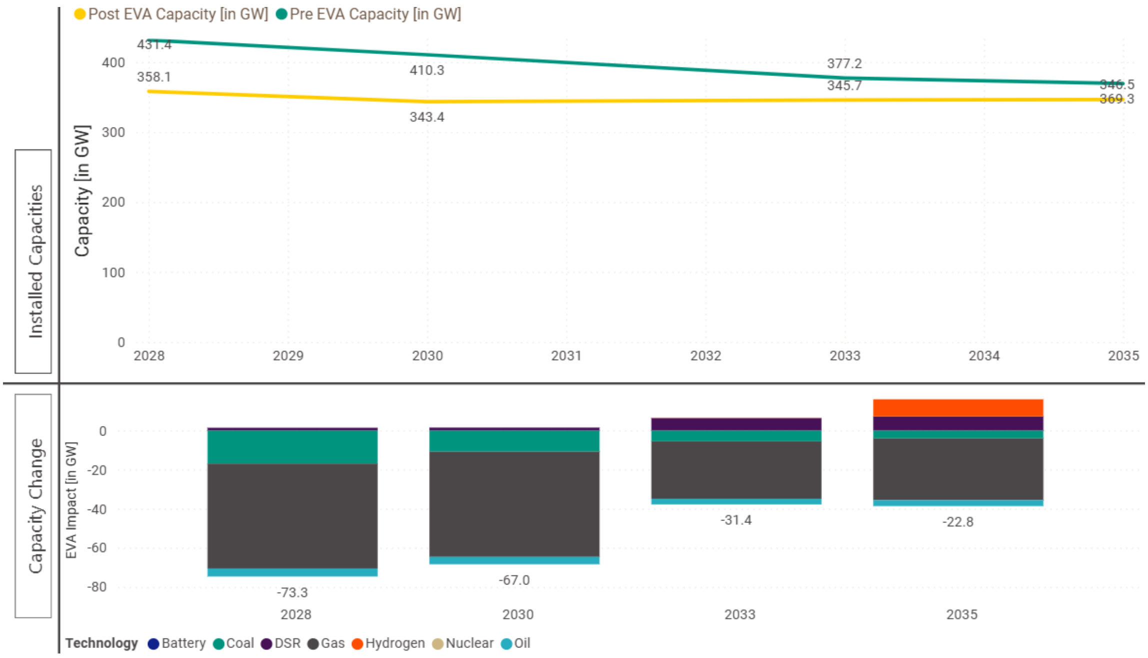


Figure 5: Net effect of the EVA on the European mix: Implementation A of revenue-based EVA

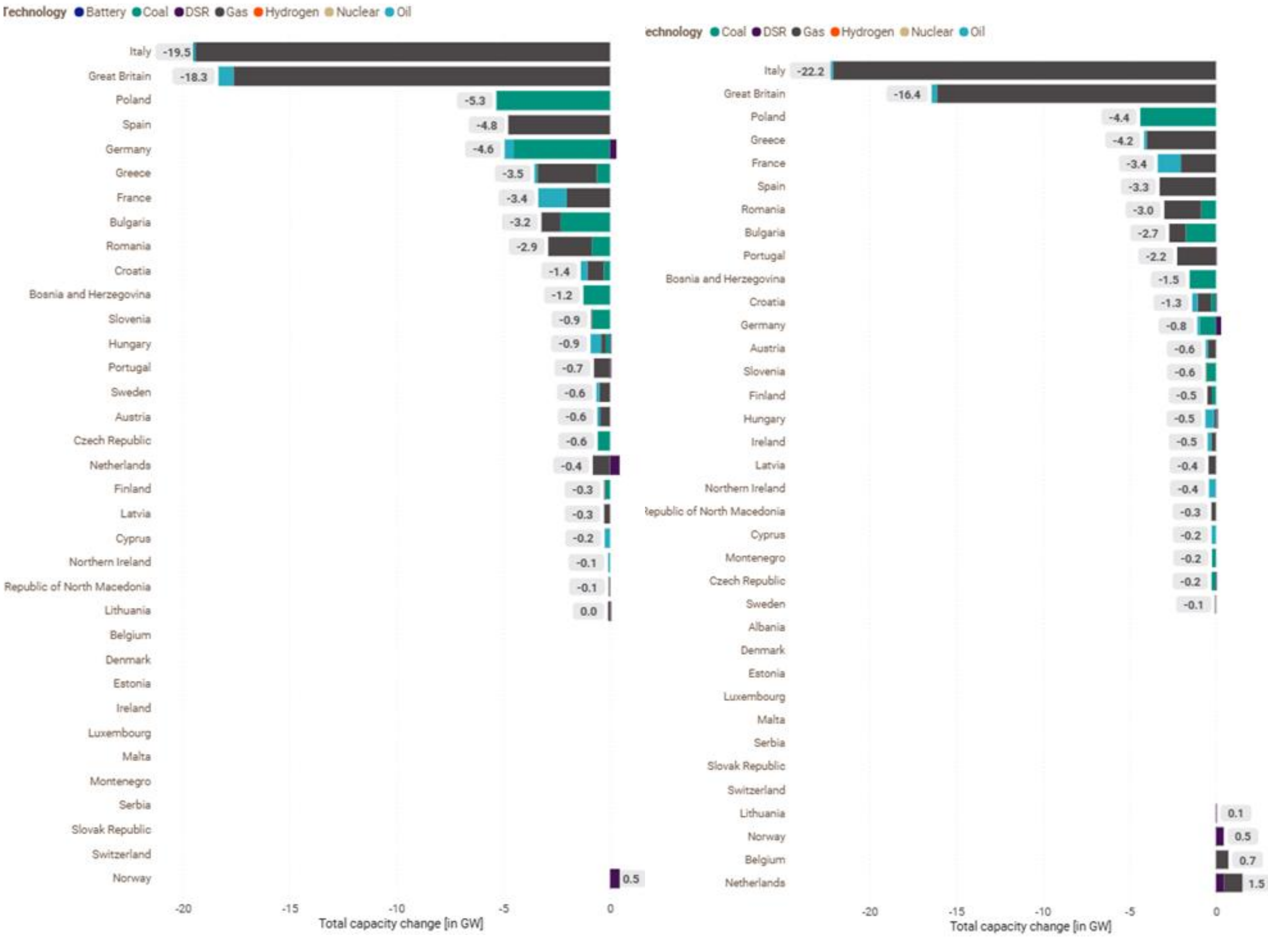


Figure 6: Detailed results for Implementation A of revenue-based EVA: 2028 (left) and 2030 (right)

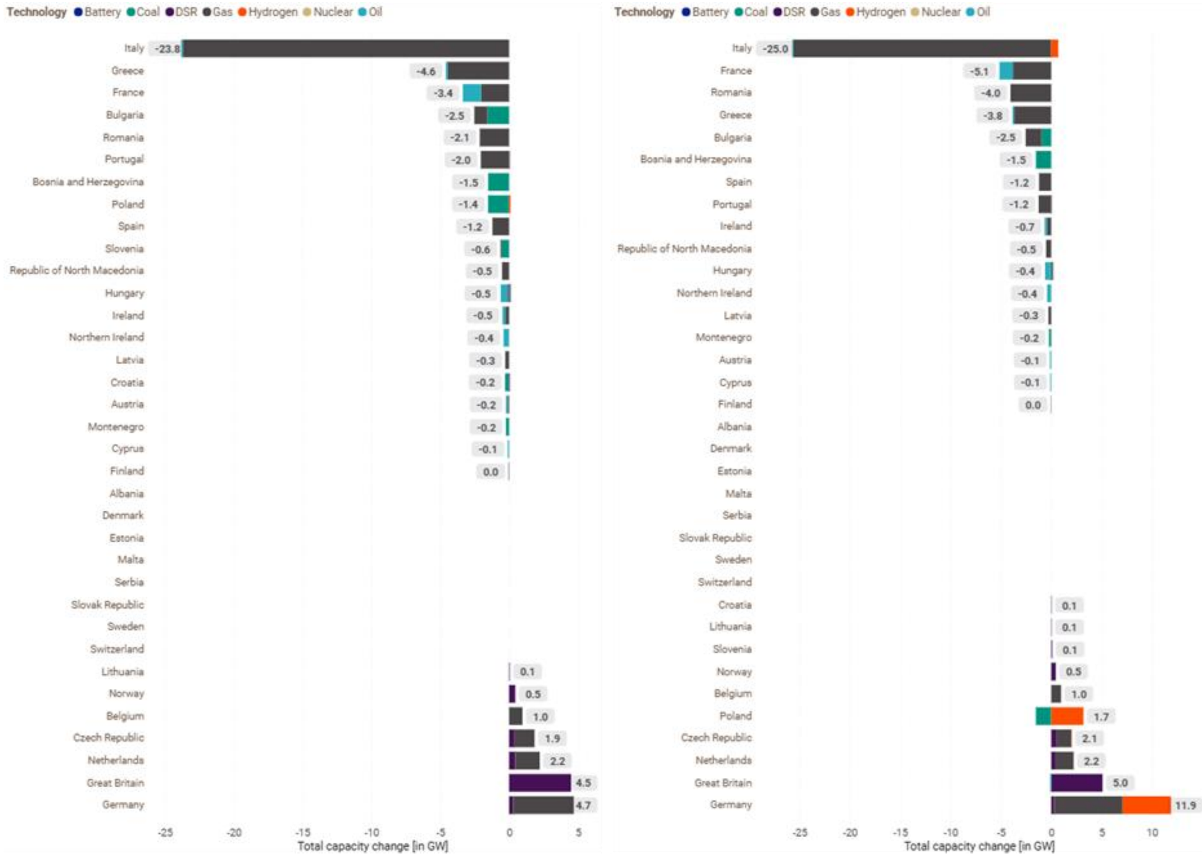


Figure 7: Detailed results of Implementation A of revenue-based EVA: 2033 (left) and 2035 (right)

3.2 Implementation B results

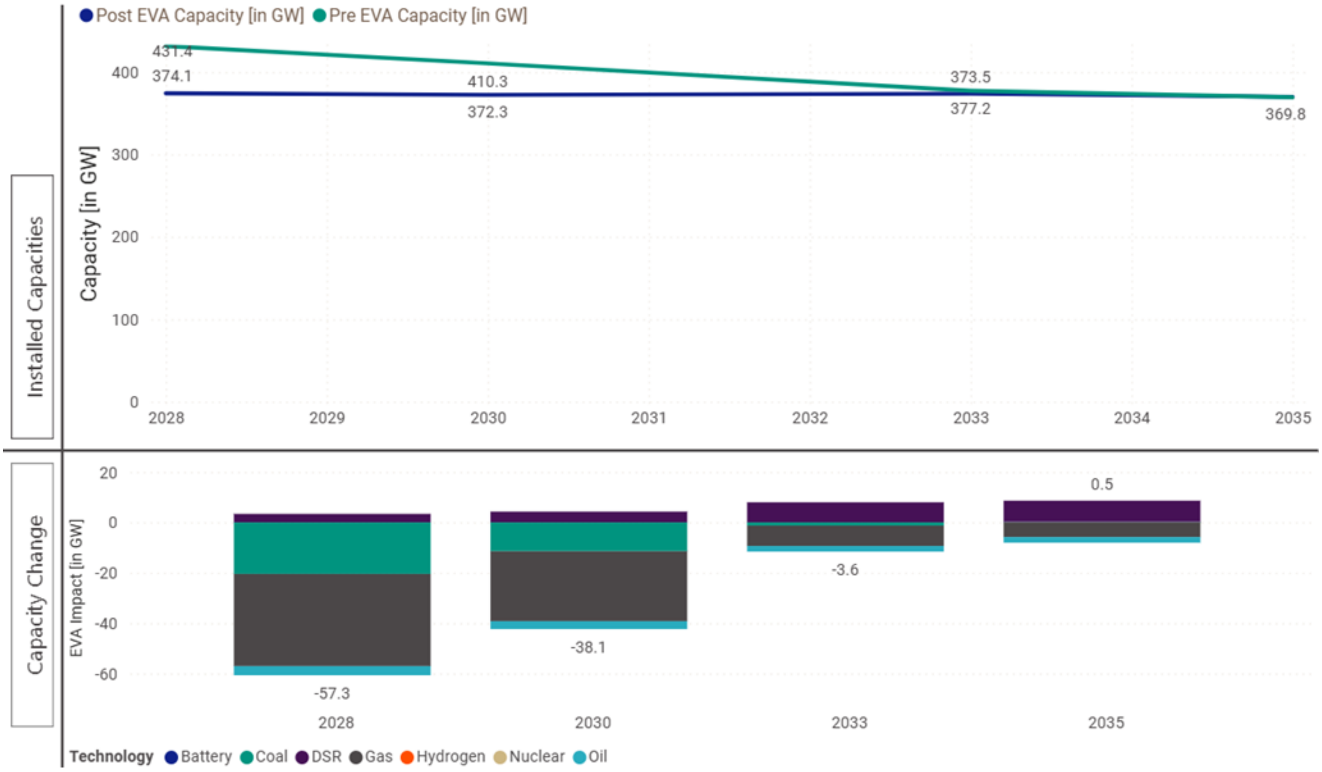


Figure 8: Net effect of the EVA on the European mix: Implementation B of revenue-based EVA

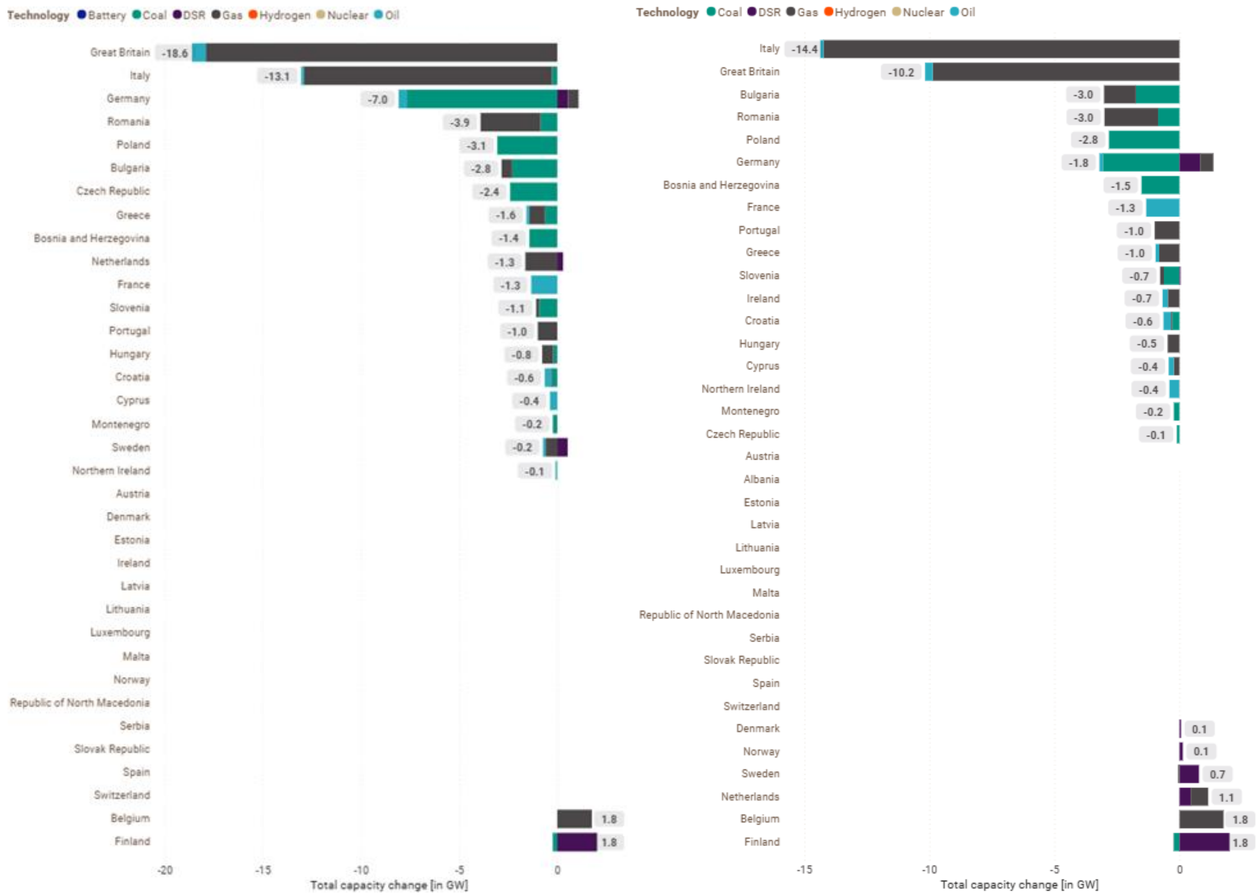


Figure 9: Detailed results of Implementation B of revenue-based EVA: 2028 (left) and 2030 (right)

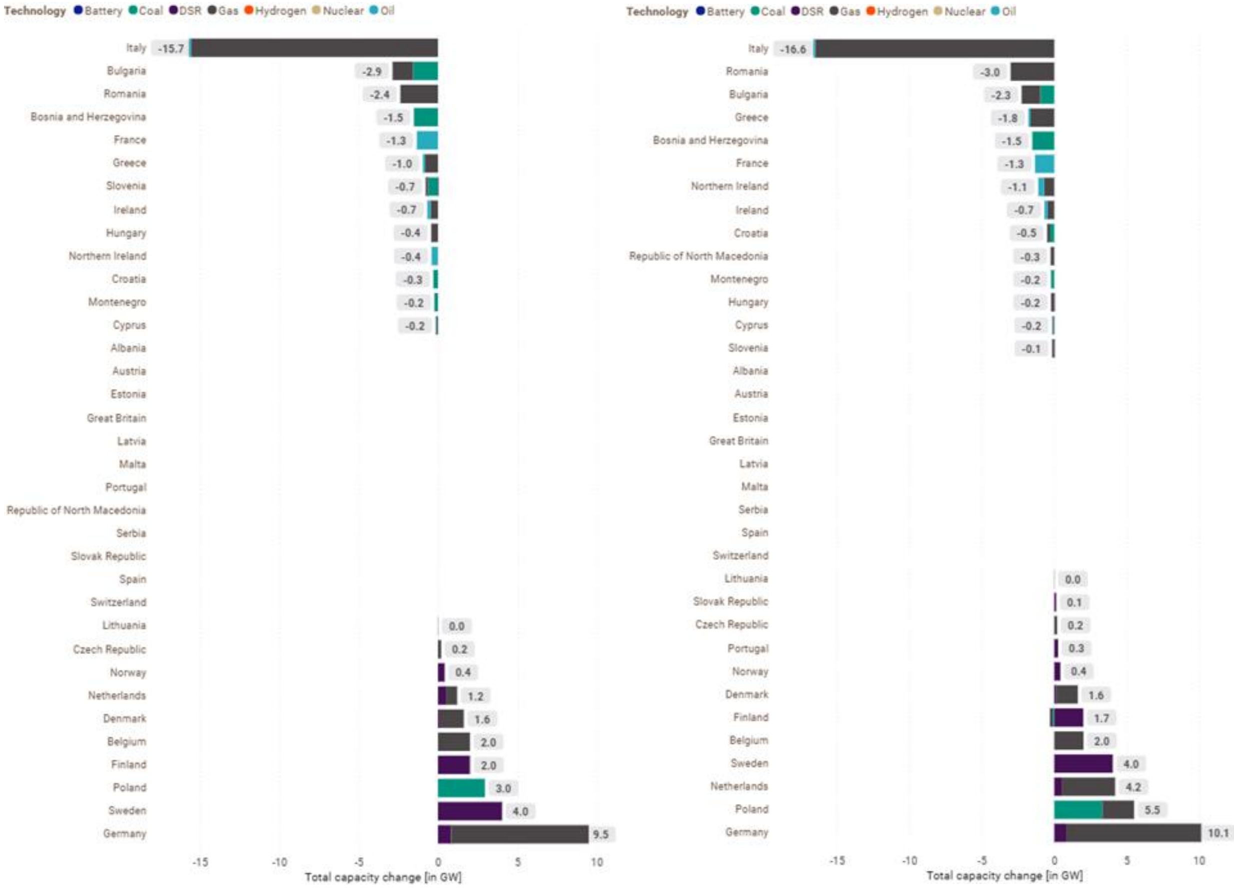


Figure 10: Detailed results of Implementation B of revenue-based EVA: 2033 (left) and 2035 (right)