ACER Decision on ERAA 2024: Annex III

DECISION No 07/2025

OF THE EUROPEAN UNION AGENCY

FOR THE COOPERATION OF ENERGY REGULATORS

on the European Resource Adequacy Assessment for 2024

Technical annex

11 August 2025

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1. Introduction

1.1. Scope of technical annex

The technical annex provides a detailed assessment of specific elements of the European Resource Adequacy Assessment 2024 ('ERAA 2024') and complements the ACER Decision; the two should be read in conjunction. The technical annex supplements ACER's assessment of ERAA 2024 concerning the high-level requirements of the Electricity Regulation (as described in section 6 of the Decision). It provides additional background for ACER's assessment. This annex is structured as follows:

- The second chapter focuses on the alignment of ERAA 2024 with the fit-for-55 target and renewable energy in particular.
- The third chapter details ACER's assessment of the economic viability assessment (EVA).
- The fourth chapter focuses on the consideration of cross-zonal capacities in ERAA 2024.

2. Fit-for-55 and renewable energy generation

2.1. Introduction

The central reference scenario of ERAA must be in line with national objectives and targets, as stated in Article 3 of the ERAA methodology. National objectives and targets stem from the EU-wide objectives and targets, implying that the central reference scenarios need to be aligned with the EU-wide policy objectives. This section examines the alignment of ERAA 2024 with the EU-wide policy objectives, for renewable energy resources. In particular, the analysis focuses on solar and wind (onshore and offshore) energy as they are expected to be the key technologies deployed for meeting the renewable energy targets.

As part of the fit-for-55 framework, the EU adopted in 2023 a binding renewable energy target of at least 42.5% of the energy mix by 2030, with the aim to reach 45%[1]. This target effectively calls for a significant increase of the renewable energy share[2]. In the electricity sector the renewable energy share would have to reach 69 % by 2030[3].

2.2. Comparison of ERAA 2024 with ERAA 2023

In order to examine the alignment of the ERAA 2024 central reference scenario with the EU-wide policy objectives, as a first step, ACER analysed the ERAA 2024 projections of renewable energy with the ERAA 2023 projections. In ERAA 2023, the capacity projections of wind and solar were well aligned with the renewable energy targets for the majority of the Member States[4]. Hence, the ERAA 2024 projections for installed renewable capacity should in principle align with or exceed those in ERAA 2023 to account for the updated renewable energy targets.

Figure 1 presents the development of installed renewable capacity for all Member States across ERAA editions in 2030. In total, ERAA 2024 assumes an additional 19 GW of installed renewable capacity as compared to ERAA 2023. This can be compared to the non-alignment seen in last year's analysis where the difference between renewable energy capacity projections in ERAA 2023 and ERAA 2022 was close to 150 GW[5]. The main technology contributing to the increase in renewable energy capacity from ERAA 2023 to ERAA 2024 is solar energy. Onshore wind further contributes to the increase, while the capacity for offshore wind is projected to decrease by 16 GW in 2030. The total renewable capacity projections in ERAA 2024 are broadly aligned or slightly exceed the assumptions in ERAA 2023. In this aspect therefore, ERAA 2024 remains broadly aligned with the renewable energy targets.

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[1] For more information, see the European Commission's webpage on the Renewable Energy Targets.

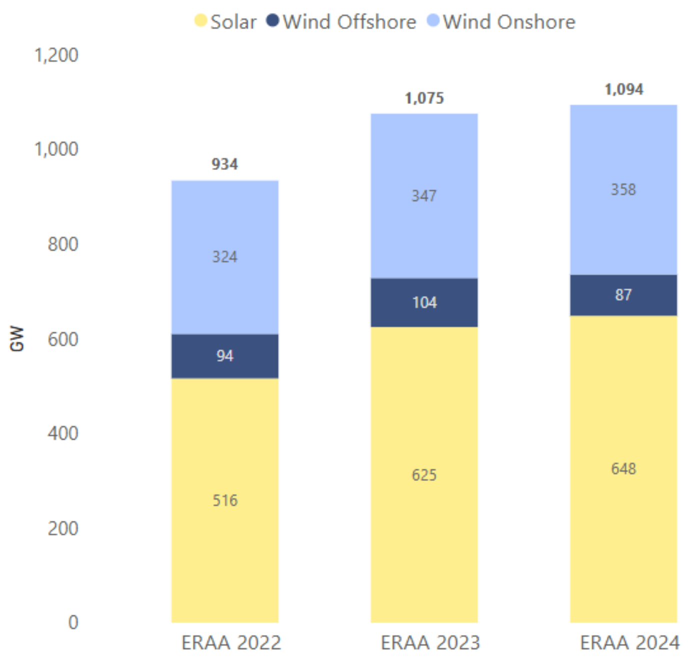
[2] According to the European Environment Agency, the share of renewables in 2023 of 24.5 % represent an increase by one percentage point from 2022.

[3] According to the European Commission, to meet the RePowerEU target of a 45% share of renewables in total energy. In 2023, about 45.3% of all electricity generated in the EU was from renewable energy sources.

[4] As described in the ERAA 2023 decision.

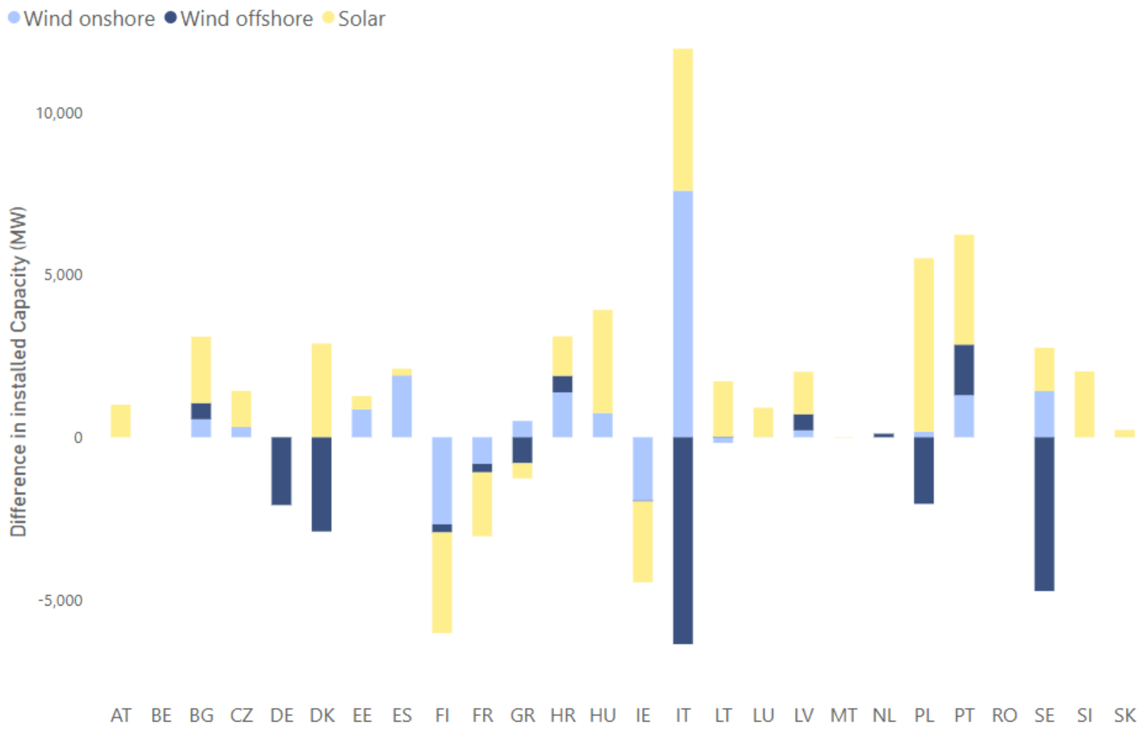
[5] In last year's analysis, the ERAA 2023 decision, the ERAA 2022 scenarios were significantly misaligned with the EU climate and energy objectives regarding the development of renewable energy for a large number of Member States. Consequently, the results showed a large increase in the installed renewable capacity in ERAA 2023 as compared to ERAA 2022.

Figure 1: Total installed renewable capacity across ERAA editions for 2030



While as a total, the renewable assumptions in ERAA 2024 compared to ERAA 2023 remain consistent, different trends can be observed at Member State level. The difference in installed renewable capacity per Member State between ERAA 2024 and ERAA 2023 is presented in Figure 2. In the figure, a positive value indicates that the assumption of ERAA 2024 is higher than in ERAA 2023. It is evident that the development varies across the Member States. While the projections of onshore wind and solar PV show both increases and decreases across the Member States, the projections of offshore wind account for a substantial decrease in five Member States. The largest decrease in offshore wind is observed in Italy, where in turn, assumptions of onshore wind and solar increase.

Figure 2: Differences in installed renewable capacity between ERAA 2024 and ERAA 2023 for 2030



Source: ACER analysis based on ENTSO-E's ERAA 2024 and ERAA 2023 data.

Note: Cyprus do not include a national estimate in ERAA 2024. Malta show no estimate of wind capacity.

There are various possible reasons for the lower assumptions of offshore wind in ERAA 2024. In the past few years, there has been a trend of lowering future projections of the installed offshore wind capacity in the EU. This development is characterized by lengthy permit processes, delayed policies and the dependence on government support to enhance investments in offshore wind, according to the JRC[6]. Regarding the assumptions of ERAA 2024, ACER received additional insight from the Swedish and Danish NRAs on the potential factors behind the decreases in offshore wind capacity compared to the previous ERAA projection in 2030. The long-term market analysis by the Swedish TSO refers to a general uncertainty in the profitability of offshore wind, which has resulted in several cancelled offshore wind projects in Europe and the US during 2023. In Sweden, the decision to finance parts of the connection costs for offshore wind farms, has been retracted[7]. This decision, combined with an uncertainty in profitability for the technology, has likely contributed to the lower assumptions of offshore wind in ERAA 2024 as compared to ERAA 2023 in Sweden.

Similarly to Sweden, the offshore wind development in Denmark is affected by uncertainties. In particular, the operation of the Energy Island Bornholm, with an installed capacity of 3 GW, has been postponed from the beginning of 2030 to later in the year[8]. This explains the example of a 3 GW lower capacity assumption of Danish offshore wind in ERAA 2024 compared to ERAA 2023. While the interest and technical potential for offshore wind to meet the future challenges of electrification persists, the market show uncertainties in its development. In relation to the cumulative EU ambition for offshore wind in 2030 of 86-89 GW, the total 87 GW offshore wind projected in ERAA 2024 still falls inside the

[6] According to the JRC on Wind energy in the European Union.

[7] According to the long-term market analysis (LMA 2024) by Svenska Kraftnät.

[8] The installed capacity of Energy Island Bornholm is not considered in the Analysis assumptions for Energinet 2023 (AF23) for offshore wind until 2031.

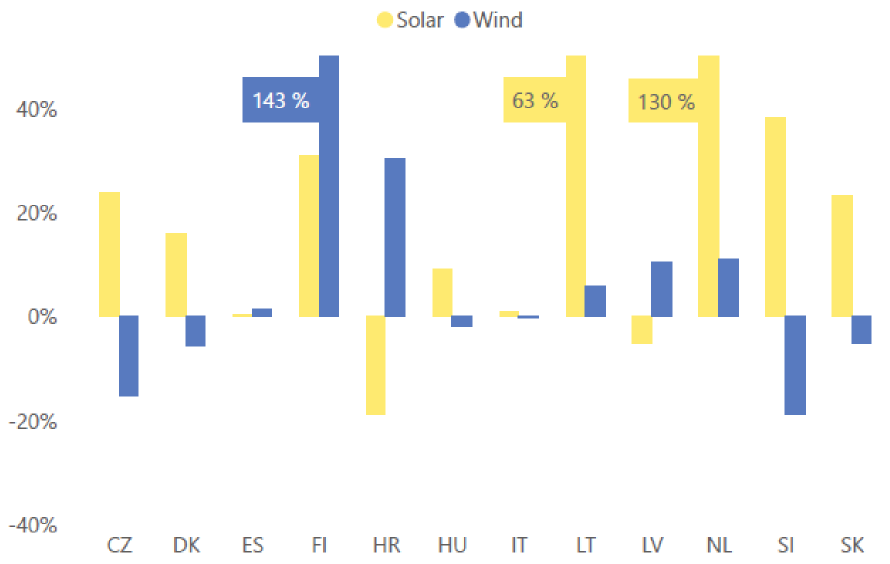
range[9]. It appears that many of these offshore developments reflect actual expectations of the development of the sector.

2.3. Comparison of ERAA 2024 with the National Energy and Climate Plans

In addition to the comparison with ERAA 2023, as a second step, ACER compared the assumptions in ERAA 2024 to the Member States' National Energy and Climate Plans (NECPs)[10]. Figures 3 and 4 present the relative differences in installed renewable capacity between ERAA 2024 and the NECPs in 2030, for the Member States above and below the NECP respectively[11]. The figures illustrate a variable alignment of the ERAA 2024 assumptions compared to the NECPs among the Member States. Due to limited availability of data behind the NECPs at the time of the analysis, the scope is limited to 24 Member States[12].

For half of the Member States studied, ERAA 2024 assumes the total installed renewable capacity will exceed the NECP in 2030, as showed in Figure 3. For three of these Member States (Finland, Lithuania and the Netherlands), the projected renewable capacity in ERAA 2024 is considerably higher than in the NECPs. As an example, in Finland the substantial investments in the grid by the TSO, are expected to facilitate the integration of renewable energy. Consequently, solar and wind energy are projected to significantly increase in the Finnish capacity mix, exceeding the scenario set in the NECP.

*Figure 3: Relative difference (%) in installed renewable capacity between ERAA 2024 and the NECPs in 2030, for Member States with the total ERAA 2024 assumptions **above** the NECPs.*



[9] The ambition of the Member States was updated following the revision of the TEN-E Regulation, suggesting an upscaling of offshore wind.

[10] The analysed data origin from the "NECP target" as stated on Ember's Live EU NECP tracker. The target represents national objectives, where they are available, or with second priority the scenario with additional measures (WAM). If neither are available in the NECP of a Member State, the with existing measures scenario (WEM) is showed.

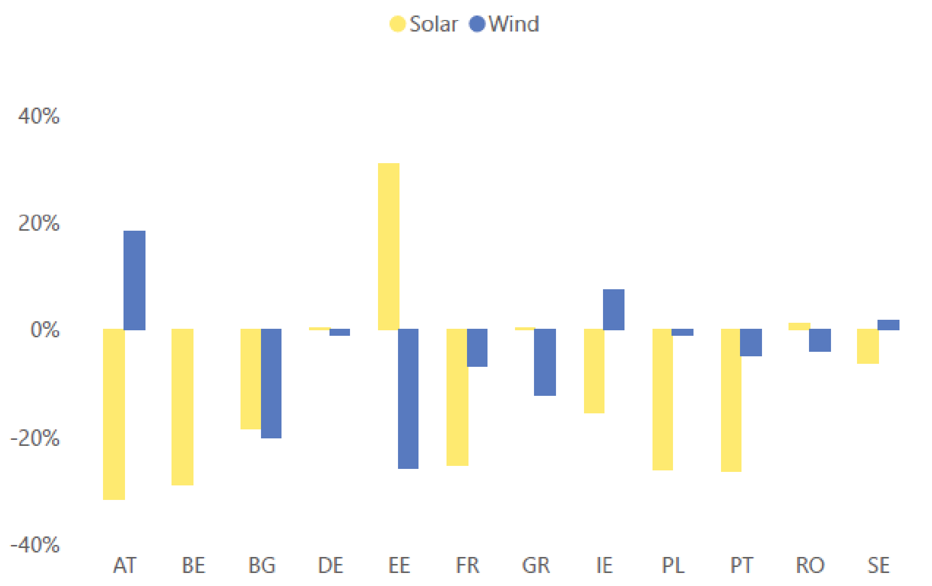
[11] For more information see the Table 4 in the Appendix which shows the absolute differences in installed renewable capacity.

[12] ACER was not able to compare the values for Cyprus, Luxembourg and Malta due to the lack of data on Ember's Live EU NECP tracker.

Source: ACER analysis based on ENTSO-E's ERAA 2024 data and the latest renewable energy target data from Ember's Live EU NECP tracker and information provided by NRAs.

For the other twelve Member States studied, the total installed renewable capacity in ERAA 2024 is projected below the capacity of the NECPs, as illustrated in Figure 4. In many cases, the difference from the NECP is prominent, with five Member States being around or more than 20 % below the NECP target (for Belgium, Bulgaria, France, Poland and Portugal). For all five Member States, except Bulgaria, it is the projected capacity of solar that is most prominently below its NECP. The reasons behind these misalignments can be various. For instance, France highlights that their NECP is still under discussion and subject to provision at the time of the analysis. Similarly, negotiations of the Belgian NECP are ongoing, resulting in no wind projection for Belgium which is therefore excluded from the analysis.

Figure 4: Relative difference (%) in installed renewable capacity between ERAA 2024 and the NECPs in 2030, for Member States with the total ERAA 2024 assumptions ***below*** *the NECPs.*



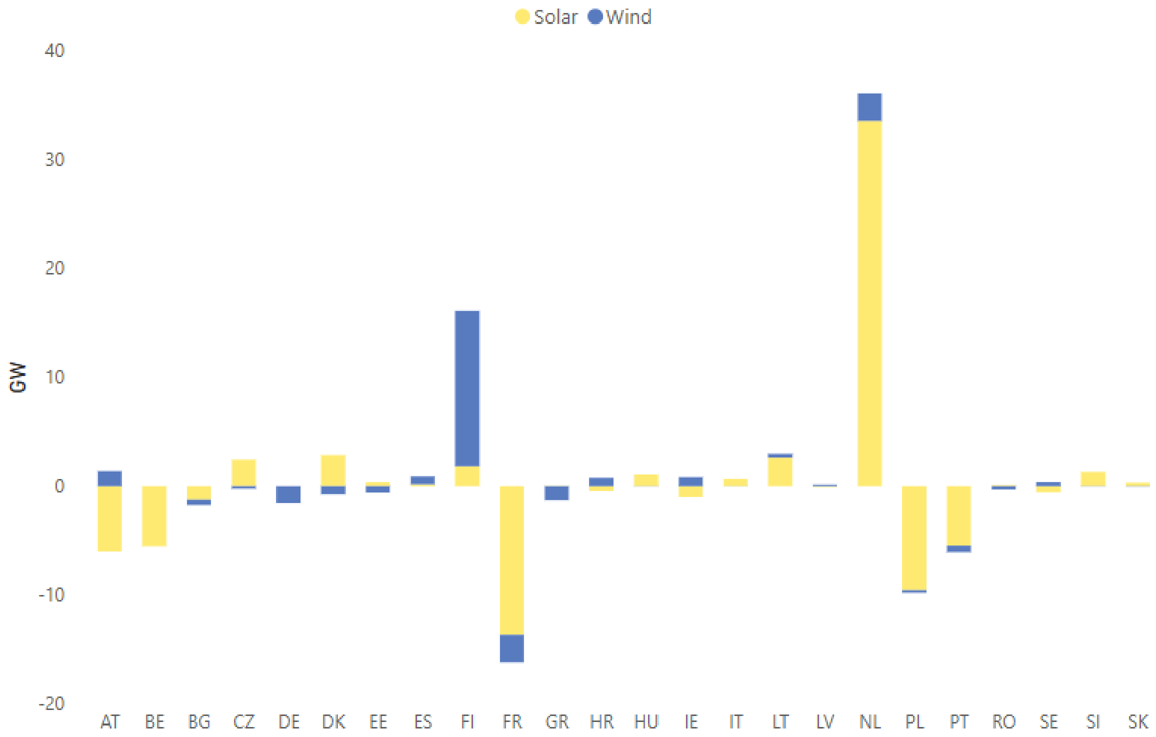
Source: ACER analysis based on ENTSO-E's ERAA 2024 data and the latest renewable energy target data from Ember's Live EU NECP tracker and information provided by NRAs.

The assumed level of renewable capacity impacts the demand-supply balance of the relevant area. While the projected capacity of ERAA 2024 may deviate from the NECPs, there are also Member States where the renewable capacity closely aligns with the NECP. For seven of the Member States (Germany, Greece, Hungary, Italy, Romania, Spain and Sweden), the total renewable capacity in ERAA 2024 is within 5 % of the NECP. Of the mentioned countries, the projections for Germany, Italy and Spain align very closely for both wind and solar capacity, as seen in Figures 3 and 4.

To complement the comparison of relative difference between the capacity assumptions of ERAA 2024 and the NECPs, ACER analysed the difference in absolute capacity. From Figure 5 it is evident that three Member States account for a large difference in capacity between ERAA 2024 and the NECPs. The Netherlands show the largest difference where ERAA 2024 assumes 34 GW more solar capacity than projected in the NECP[13]. This highlights the large impact of these Member States in particular on the total outlook of renewable energy for the EU.

[13] For the values behind the renewable assumptions of ERAA 2024 and the NECPs, see table 4 in the Appendix.

Figure 5: Difference between the projected installed capacity in ERAA 2024 and the NECP, in 2030



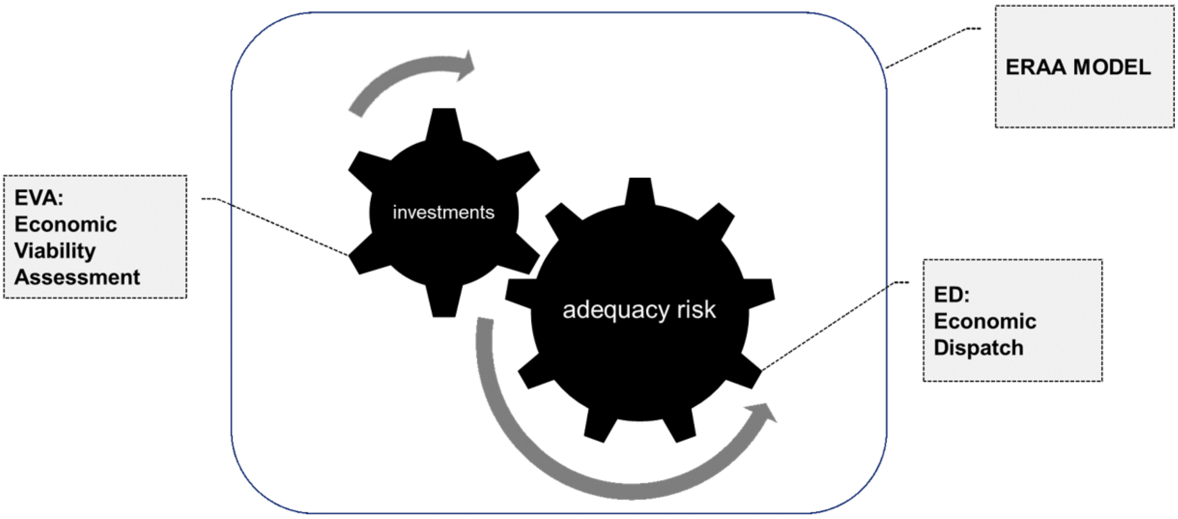
To conclude, despite variations and outliers among Member States, for a majority of the countries, when considering the development of both wind and solar, the projections in ERAA 2024 are broadly aligned with the renewable energy targets. In total, the ERAA 2024 projections of both wind and solar capacity align closely with the total NECPs (3 % above and 0.6 % above the targets respectively in 2030). The deviations of solar PV assumptions for certain Member States highlight the need to revisit these assumptions in the next ERAA edition to further reflect the renewable energy targets of the EU in 2030.

3. Economic viability assessment

3.1. Introduction

The purpose of the economic viability assessment (EVA) is to assess economic decisions about entry and exit of capacity resources in the electricity market, based on expected revenues and associated costs. As in previous editions of ERAA, ERAA 2024 formulates the EVA as an optimisation problem that minimises total (fixed and operating) system costs. The output of the EVA module in terms of capacity available in the system for the modelled time horizon is the input of the economic dispatch (ED) module that is used to estimate adequacy risks.

Figure 6: The ERAA 2024 model consists of two modules



The ERAA 2024 describes the methodology of the EVA in Annex 2 (Chapter 10) and presents the results of the EVA in some detail in Annex 3. In addition, and upon ACER's request, ENTSO-E provided ACER with supplementary data regarding the adequacy risk indicators of the EVA and ED module runs with and without the implementation of curtailment sharing.

The following sections examine some of the key developments of the EVA in ERAA 2024 compared to ERAA 2023.

3.2. Consistency between the EVA and the economic dispatch modules

The consistency between the EVA module and the economic dispatch (ED) module is vital for the validity of the ERAA. The EVA aims to predict the level of new investments and market exits that can be expected based on market conditions. Ideally, this assessment would be performed at the same detail and assumptions in both modules, i.e. with the same level of hourly aggregation and for the same weather scenarios and outage patterns, as these are the underlying market conditions of ERAA.

Figure 7shows the comparison of the average LOLE indicators between the EVA and ED module for all zones and all target years. Notable differences can be observed, with average increases ranging from 1.7h to 4h of LOLE depending on the target year considered[14]. These differences highlight that perceived adequacy risks are not the same between the two modules, hence that scarcity situations and pricing are not accurately reflected in the EVA, distorting investment signals.

Figure 77: Comparison of average LOLE between the EVA module and the ED module – Central scenario, all bidding zones but MT00, all target years

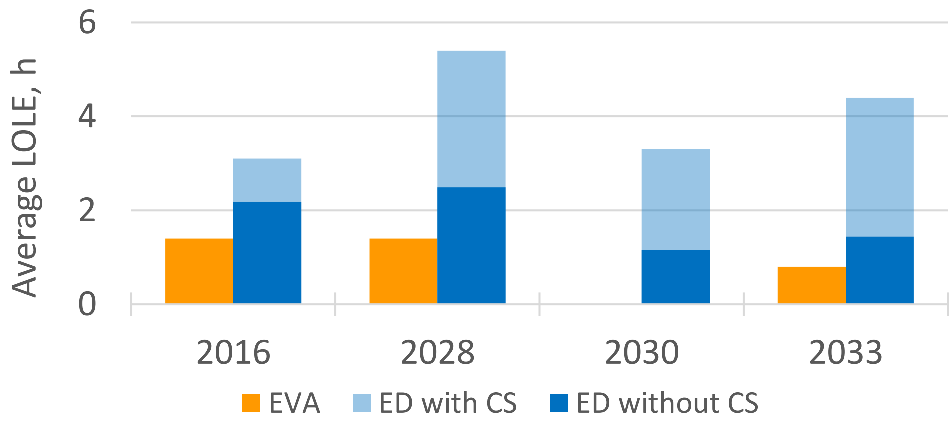


Figure 8 and Figure 9 show the comparison of gas technology revenues between the EVA and ED modules per bidding zone. The net revenues are generally lower in the EVA module. In 2035 the revenues are consistently lover for all bidding zones, whereas in 2028 the average revenue is 36 €/MW in the EVA module and 44 €/MW in the ED module. The 2028 target year comparison is not uniform, with some bidding zones having lower revenues in the ED than in the EVA.

[14] For the sake of the comparison, MT00 zone was excluded, considering its high LOLE level that skews the average LOLE value.

Figure 8 Average net revenues per MW in EVA and ED models for 2028 gas technology

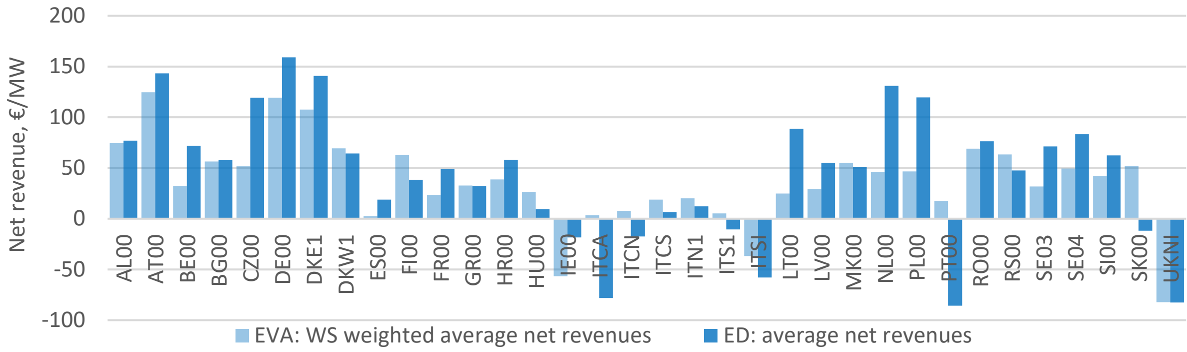
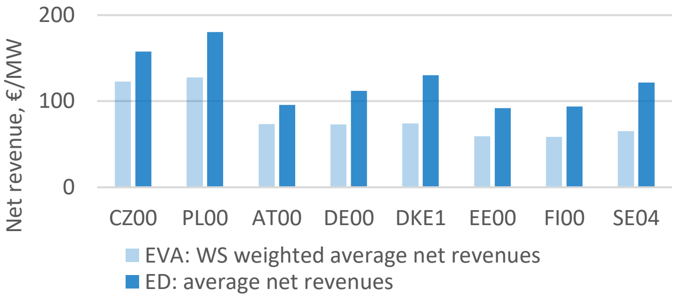


Figure 9 Average net revenues per MW in EVA and ED models for 2035 gas technology



The differences between the results of the EVA and the ED result from the combination of several simplifications introduced in the EVA module to cope with computational difficulties. The most important of these simplifications are the reduction of the modelled weather scenarios from 36 in the ED to 3 in the EVA, the different flow-based domains used (discussed in section 4), the divergent modelling of forced outages and the fact that local matching and curtailment sharing are only implemented in the ED module[15]. In future ERAA versions, ACER expects that revenues further align between the EVA and the ED.

3.3. Curtailment sharing

The objective of this section is to describe the additional information requested by ACER following the sharing of its preliminary position as well as the answers provided by ENTSO-E. The new information aimed to enhance the understanding of the curtailment sharing feature to assess its robustness. Indeed, in its previous decisions, ACER highlighted substantial issues regarding the modelling assumptions and the implementation of curtailment sharing.

3.3.1. ACER's preliminary position

During the ERAA development process, ENTSO-E informed ACER that ERAA 2024 differs from ERAA 2023 in its approach to modelling of local matching and curtailment sharing. Both features were integrated into the optimisation of the economic dispatch module to replicate the functioning of the EUPHEMIA algorithm of the single day-ahead coupling. In previous ERAA versions, only local matching

[15] There are other simplifications in the EVA that contribute to the mismatch between the EVA and the ED module. These include for example, the way aggregated capacity values form the EVA module are postprocessed to enable unit-by-unit consideration in the ED module, and the use of derating to model maintenance profiles in the EVA.

was endogenized and curtailment sharing was a post-processing process that only redistributed ENS across bidding zones. ACER notes that Annex 2 of the ERAA 2024 Report states that curtailment sharing was implemented as an “integrated post-processing mechanism” in ERAA 2024, contrary to a “post-processing mechanism” in ERAA 2023 but does not provide further details on how the two approaches differ. Without further information at the time of its preliminary position, ACER was initially unable to determine whether this improvement was effectively implemented or not, or its potential impact on the results.

The EUPHEMIA algorithm equalises the curtailment ratios of price taking orders across bidding zones. According to the ERAA 2024 report, the curtailment sharing feature replicates the function of EUPHEMIA by equalising the ENS ratios of bidding zones that are simultaneously in a domestic capacity deficit. ACER considers that this approach, as described in the ERAA 2024 report, may undermine the contribution of cross-border exchanges, as bidding zones in a domestic capacity deficit without ENS pre-curtailment sharing may get assigned ENS, without considering their ability to import. Bidding zones that are not in overcapacity are likely to be the most impacted. Consequently, this approach may fail to account for the contribution of interconnections, as required by Article 1(2)(m) of the ERAA methodology.

Considering the information available in the ERAA 2024 report as well as in ERAA 2023 report, ACER also identified non-intuitive cases where system-wide ENS increased when comparing pre- and post-curtailment sharing ED results of ERAA 2024. On the other hand, the ERAA report indicates that “the implementation of curtailment sharing does not affect the adequacy results in terms of system ENS occurrences”, which contradicts the observed behavior of the feature. These non-intuitive cases suggest there would be scope for further improvement in the implementation of the curtailment sharing feature that may currently lead to increased perceived adequacy risks.

3.3.2. Request for information

To enhance the understanding of how curtailment sharing functions in ERAA 2024, ACER requested detailed information regarding the curtailment sharing feature. The requested details also align with the insights ACER aimed to obtain through the analysis (case-study) it had called for in the ERAA 2023 Decision. The information requested included the following elements:

i. The precise formulation of the curtailment sharing feature in ERAA 2024 and the reasoning behind the use of the domestic capacity deficit as a proxy for price-taking orders used in the EUPHEMIA algorithm.
ii. Explanations of the integration of the curtailment feature into the ED module, supposedly performed for the purpose of ERAA 2024 and any other changes or improvements brought to the curtailment sharing feature for the purpose of this year’s ERAA.

Additionally, to ensure proper implementation of the curtailment sharing feature, ACER shared with ENTSO-E three illustrative examples (application cases) on how the sharing of curtailment between bidding zones would be done in ERAA 2024.

3.3.3. ENTSO-E’s answers

In response to ACER’s request for information, ENTSO-E provided a description of the functioning of the curtailment sharing feature for the purpose of ERAA 2024. This description clarified how the curtailment sharing feature was implemented in ERAA 2024 and how it replicates the adequacy patch of the EUPHEMIA algorithm. Additionally, it highlighted that sanity checks were introduced in ERAA 2024 process. They are used for all scarcity hours to ensure proper sharing of the curtailment. Finally, ENTSO-E provided comments to ACER’s three illustrative examples, showcasing that cross-border exchanges and flow factor competition were, in principle, properly accounted for when sharing ENS.

Considering the impossibility to fully replicate the EUPHEMIA algorithm as bids are not modelled in ERAA, ACER considers that, based on the received information, using domestic capacity as proxy to price-taking orders is an acceptable approach. The information provided also confirmed that the curtailment sharing feature has not been integrated further within the ED module compared to ERAA 2023. Hence, as in previous ERAA versions, only local matching constrains are endogenized in the ED optimization, while curtailment sharing remains a post-processing step. ENTSO-E highlighted the increasing computational burden that prevented the integration of curtailment sharing. Acknowledging this aspect, ACER considers this simplification acceptable.

ACER welcomes the answers, as they include details about the curtailment sharing feature that ENTSO-E has not shared before. Specifically, the answers explain how, for some scarcity hours, system-wide ENS may increase after curtailment sharing contrary to how Annex II of the Report explains the methodology. This clarifies the cases that previously seemed unintuitive under the Report's description. In that sense, relevant sections of the Report shall be amended to reflect the actual implementation of curtailment sharing in ERAA.

3.3.4. Pre- and post-curtailment sharing analysis

Analysis of ERAA 2022 and ERAA 2023 results indicated that the implementation of local matching and curtailment sharing features in the ED module was a key driver for the resulting inconsistencies between the ED and the EVA[16]. As in previous ERAA editions, ENTSO-E provided to ACER results before and after the implementation of the curtailment sharing in the ED module (Figure 1010). Analysis of this data shows that the overall differences between the EVA and the ED remain, with European-wide[17] LOLE increases due to curtailment sharing ranking from +92% to +194% depending on the target year considered. As highlighted in Section 6.2.5 of the Decision and in the amended Section 11.7. of Annex: Methodology of the report, although such increasing trend is expected in theoretically, empirical analysis would be beneficial to ensure proper implementation of the curtailment sharing feature.

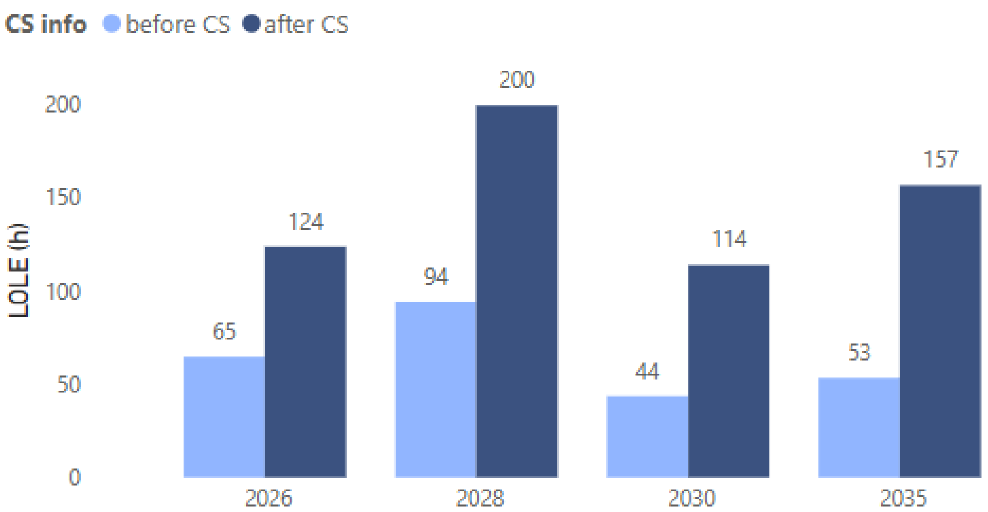


Figure 10: Differences between the average LOLE from the ED module with and without the implementation of curtailment sharing – Central scenario, all Member States but IE00 and MT00, all target years

[16] See section 3.2 of Technical Annex of the ERAA 2022 Decision.

[17] Excluding IE00 and MT00 whose high level of LOLE skew the comparison. The values are without out-of-market measures.

3.4. Maximum clearing price

According to Article 7 of the ERAA methodology, paragraphs 7(8) and 7(9), the assessment needs to reflect price formation during hours when scarcity occurs in a modelled zone, i.e. during periods of ENS. The ERAA methodology further specifies that the price during scarcity periods should equal the harmonised maximum clearing price in line with Articles 10 of the Electricity Regulation, unless Member States apply any indirect restrictions to wholesale price formation.

As in ERAA 2023, ERAA 2024 uses price caps that evolves with each target year modelled. The original intent of the price evolution was to replicate the criteria and process for adjusting the harmonised maximum and minimum clearing prices for SDAC, as described in ACER Decision 2023/01[18], inducing price cap increases following repeated price spikes. As the dynamic price cap increases cannot be modelled endogenously, a yearly evolution is based on the occurrence of price spikes in the Economic Dispatch (ED) runs of the previous version of ERAA. The resulting price cap levels are shown in Table 1 below

Table 1: Price cap evolution in different ERAA (EUR/MWh)

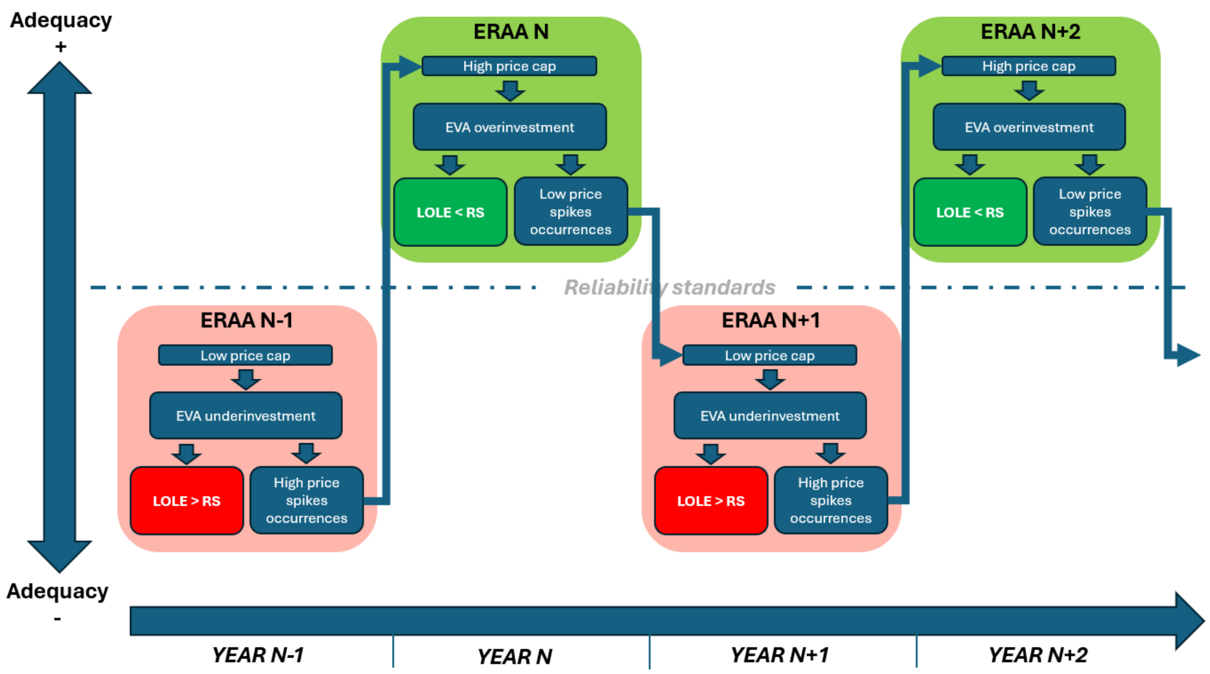
Target year modelled	2024	2025	2026	2027	2028	2029	2030	…	2033	…	2035
ERAA 2021	-	15000	-	-	-	-	15000	-	-	-	-
ERAA 2022	5000	5000	6000	6000	7000	8000	8000	-	-	-	-
ERAA 2023	-	4500	-	-	6000	-	7000	-	8500	-	-
ERAA 2024	-	-	4500	-	5000	-	6000	-	-	-	6500

These close links between the price cap in one ERAA edition and price spikes in the preceding ERAA edition bring certain concerns. As price spikes occur during scarcity, the adequacy outcomes of the previous ERAA would impact the evolution of the price cap. Consequently, the previous ERAA adequacy outcomes would affect the EVA results of the current ERAA because the commissioning, decommissioning or mothballing decisions will depend on the price cap. As an example, should an ERAA version identify a substantial number of scarcity situations, leading to a high number of price spikes, the price cap of the next ERAA version will increase, hence increasing the profitability of capacities subject to the EVA, and decreasing the occurrence of scarcities situations.

[18] Harmonised maximum and minimum clearing prices for SDAC: nemo-committee.eu/assets/files/ACER%20Decision%2001-2023%20on%20HMMCP%20SDAC%20-%20Annex%201-ac8ad8689e50f1338ecbef2cb1239bb2.pdf

As highlighted in Section 6.2.5, ACER highlights a risk of cyclical adequacy risks assessment due to the functioning of the price cap computation, with ERAA versions alternating between resource adequacy and resource scarcity, as illustrated in Figure 1111 below.

Figure 11: ERAA adequacy outcomes dependencies and dynamics



In that sense, ACER recommends that ENTSO-E modifies its maximum clearing price approach to decouple the computation of price caps with previous ERAA outcomes.

Additionally, ACER considers that ENTSO-E's assumption on the maximum clearing price is not aligned with the applicable regulatory framework. Like previous ERAA editions, ERAA 2024 omits the intra-day and balancing energy markets, both of which have higher maximum clearing prices. This is particularly important for peaking resources that tend to operate for a limited number of hours, such as demand side response and open cycle gas turbines. In ACER's view, the ERAA should consider the technical bidding limits of at least the day-ahead and intra-day markets in conjunction.

3.5. Demand side response

ACER considers that the level of simplifications is acceptable in ERAA 2024, but - given the enhanced role of DSR in an increasingly decarbonised power system - ACER recommends ENTSO-E to further improve the modelling of these resources in ERAA 2024.

Regarding explicit DSR, there is scope to improve the centralised ENTSO-E approach and better reflect the existing or future explicit DSR levels in the ERAA (e.g., DSR contracted through capacity mechanisms, beyond the duration of their contracts). Where national DSR assessments are used, ACER expects that ERAA 2024 provides more transparency on those inputs.

DSR capacities for target year 2030 are plotted in Figure 1212 for two ERAA editions: 2023 and 2024. EVA expansions (in orange) are added on the top of the national estimates (in green). No DSR capacity is reported for Italy in 2024, whereas in 2023 Italy has about 2 GW. Additionally, significant DSR capacity decrease can be observed in Ireland: from 667 MW in ERAA 2023 to 142 MW in ERAA 2024.

On the other hand, the EVA adds about 5 GW more DSR European-wide comparing with previous ERAA edition.

Relative change in DSR capacity in 2030 is depicted in Figure 13. It compares how the final DSR values – national estimates + EVA expansion – changed in ERAA 2024 comparing with the previous edition. At best, the EVA adds significant DSR capacity in Sweden in ERAA 2024 (about 5 GW - 270% DSR capacity increase in Sweden comparing with previous ERAA). This is the highest change in both relative and absolute values.

Figure 12 Demand Side Response capacity in 2030: ERAA 2023 vs 2024

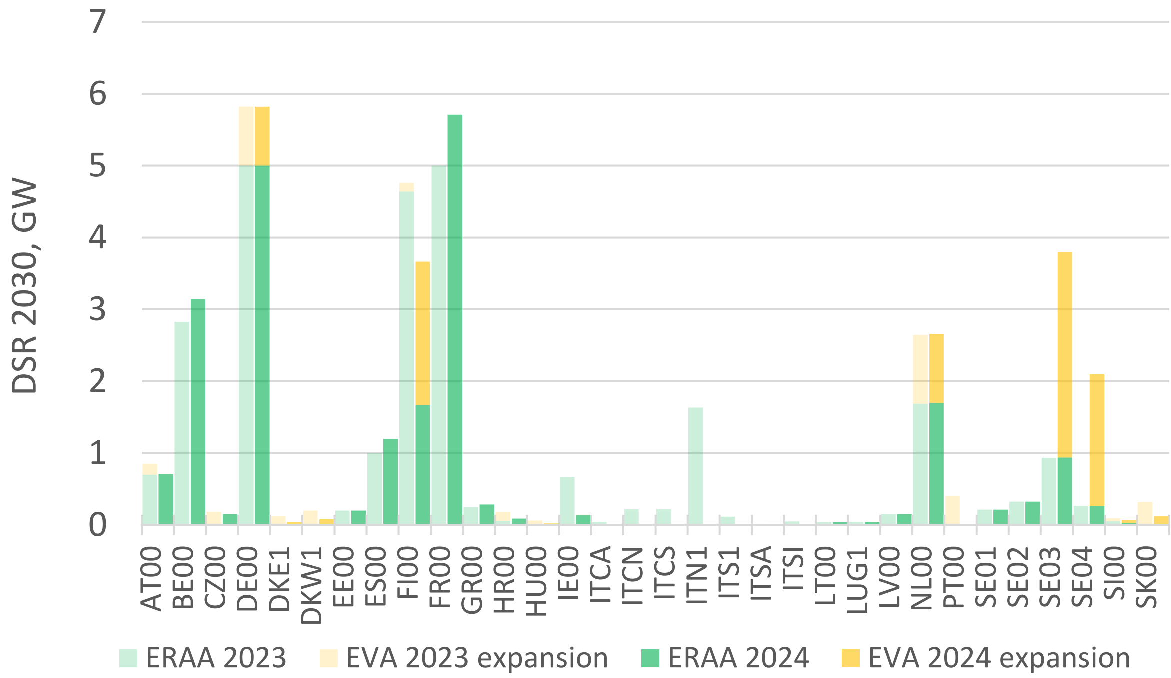
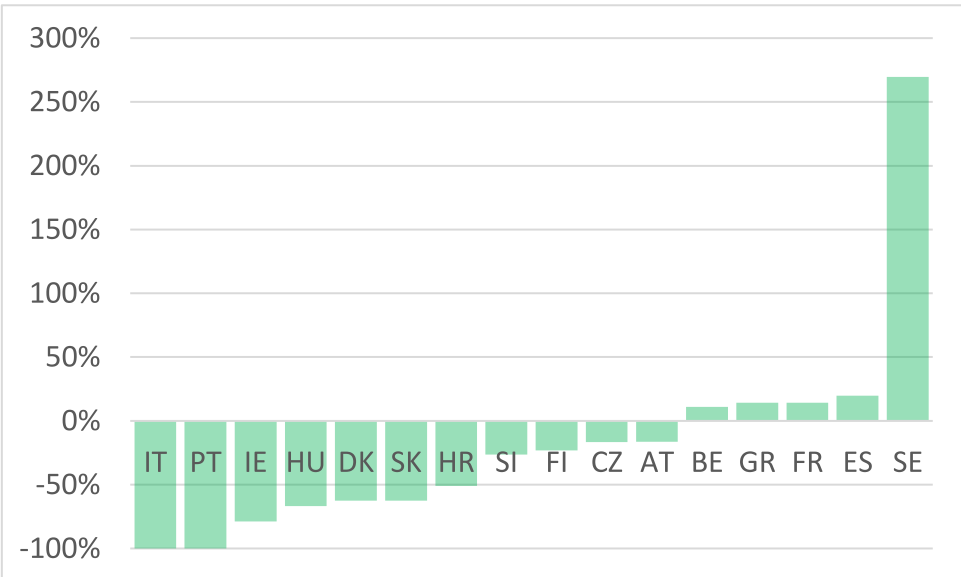


Figure 13 Relative DSR capacity change in 2030: ERAA 2023 vs 2024



Regarding implicit DSR, and as highlighted in Section 6.2.8. of the Decision, future ERAAs would benefit from clear justifications about the basis for the assumed flexibility related to electric vehicles and heat pumps. ENTSO-E should also consider incorporating flexibility from other electricity uses. ACER also expects that in the future ERAA cycles, new support schemes for clean flexible resources, such as DSR and storage, will be appropriately reflected.

4. Cross-zonal capacities

4.1. Introduction

This section focuses on the approach to cross-zonal capacities in the ERAA 2024 central reference scenarios. The review of cross-zonal capacity covers the following topics:

- Network developments taken into account in the context of capacity calculation;
- Capacity calculation methodologies; and
- Compliance of cross-zonal capacities with the so-called minimum 70% target.

4.2. Network development

Pursuant to the Electricity Regulation, the ERAA must properly take into consideration the level of interconnection, interconnection targets, and real network development (requirements of Article 23(5)(m), Article 23(5)(b) and Article 23(5)(l) respectively). Article 3 of the ERAA methodology specifies that the assessment must reflect best estimates about the future state of the network based on the latest national development plans and ENTSO-E's Ten-Year Network Development Plan (TYNDP). Article 4 of the ERAA methodology specifies the modelling framework for the electricity network.

For the Core region, the ED module, and for the first time the EVA module as well, applies a flow-based approach with differentiated flow-based domains for each target year. The grid models used for the calculation of the flow-based domains are from the TYNDP 2022 National Trends scenario adjusted for ERAA 2024 target years. Flow-based domain for all target years (TY) are computed using outcomes of the ERAA 2023 results for climate years 1998 (high RES), 2010 (high residual demand) and 2014 (low demand).

ACER acknowledges the improvement in ERAA 2024 compared to the ERAA 2023 regarding the consideration of network developments in the ED. The calculation of flow-based domains for all target years individually and consistently between the ED and EVA is considered the best approach regarding the network development representation.

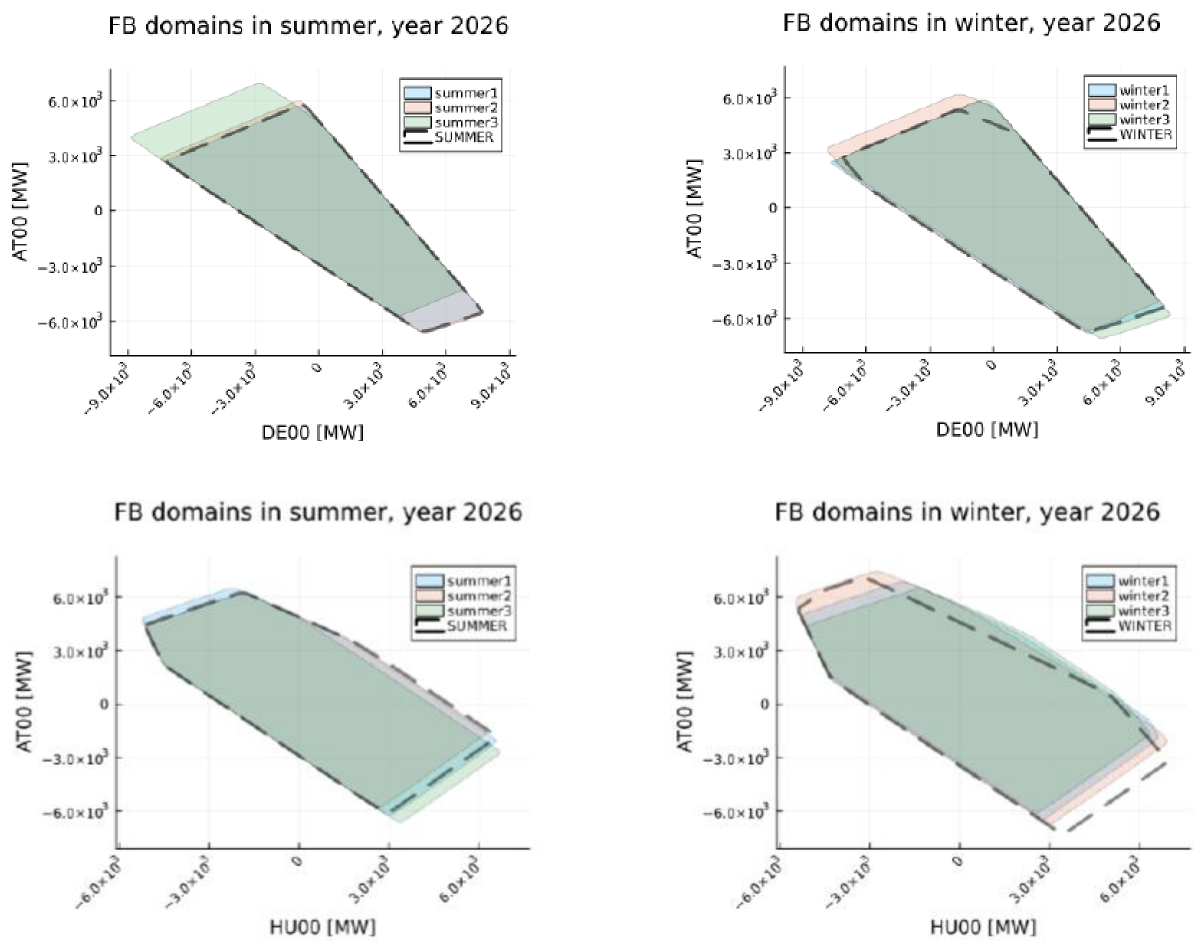
4.3. Capacity calculation methodologies

To improve the consistency between the cross-zonal capacities of EVA and ED for the same target year in ERAA 2024, ENTSO-E has applied the flow-based approach in the ED and EVA modules for the Core CCR. For the ED module ENTSO-E has increased the number of flow-based domains from four to six per target year. However, due to computational complexity, the EVA module in ERAA 2024 is using only two flow-based domains per target year. In this case, proper representation of the set of the ED domains when reducing FB domains for the EVA is important. In ERAA 2024, ENTSO-E has followed clustering techniques used in the past editions with the objective to reduce the number of FB domains from 8760 (for one year) to 6 for the ED and 2 in the EVA.

Certain assumptions and simplifications have been used when computing the flow-based domains, mostly consistent with previous ERAAs. The FB domains for ERAA 2024 are derived from the ED results of ERAA 2023, though ERAA 2023 used different weather scenarios than ERAA 2024. Additionally, to approximate the ED outcome, the 2025 results were used for the 2026 FB domains, and the 2033 results for the 2035 FB domains.

Due to the different number of flow-based domains used in the ED and EVA, full consistency regarding the capacity calculation between the two modules cannot be expected. The Joint Research Centre conducted an analysis using data available in raw files by ENTSO-E[19]. Although, the direct impact of the FB domains on EVA and ED outcomes cannot be fully assessed from raw data alone, analysing a few examples of FB domain projections offers valuable insights. The 'shape' of the FB domains by projecting them onto two dimensions for the six domains used in the ED and the two domains used in the EVA was analysed. The analysis covers three pairs of study zones: AT-DE, AT-HU, and DE-NL. Figure 14 shows the cross-section projection of flow-based domains onto the AT-DE, AT-HU and DE-NL.

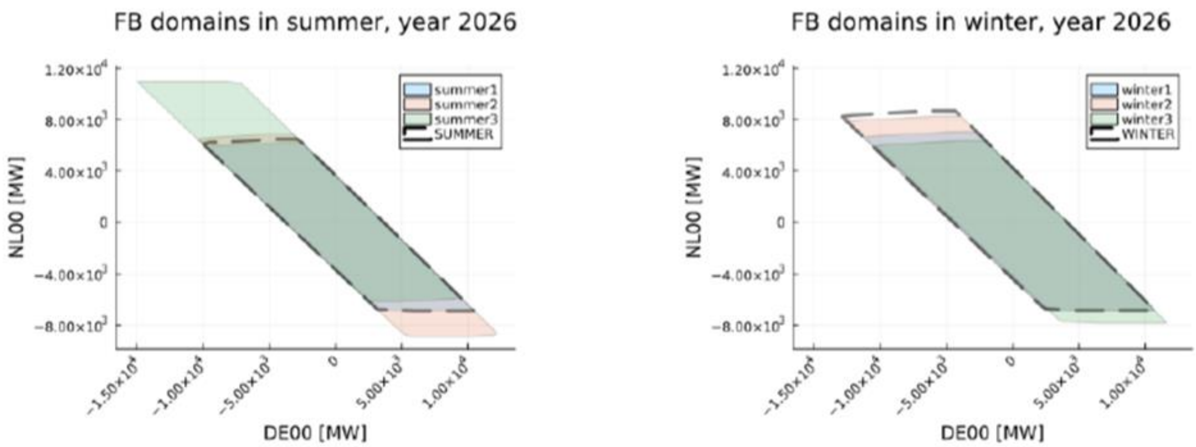
Figure 14: Illustration of the cross-section projection of flow-based domains onto the a) AT-DE, b) AT-HU and c) DE-NL space. On the left summer domains are displayed, while on the right, the winter domains are depicted. The coloured domains represent FB domains used in the ED module, whereas the dashed-line FB domain is intended for use in the EVA module.



a)

b)

[19] https://www.entsoe.eu/outlooks/eraa/stakeholder-interactions/



c)

Source:JRC own elaboration.

From Figure 14 a key observation is that the shape of the FB domains remains fairly consistent across the different FB domains. This stability can be attributed to the strong link with the physical properties of the grid and the uniform GSK strategy applied across all FB domains. Moreover, the FB domains used for EVA appear to be sufficiently representative of a broad range of FB domains. However, large FB domains can still vary significantly between the EVA and ED, as seen in the case of DE-NL. This discrepancy implies that the EVA may not adequately signal the need for capacity investments during shortfall hours.

ACER acknowledges the improvement in ERAA 2024 compared to the ERAA 2023 regarding the use of flow-based market coupling in the EVA along with the use of flow-based market coupling in the ED. This approach can improve the consistency between the ED and the EVA regarding the capacity calculation methodologies.

For next year's ERAA ENTSO-E should strive to include a more solid solution to ensure full consistency between cross-zonal capacities in the two models of the ERAA, by either using the same set of flow-based domains between models or ensuring that the reduced set of flow-based domains in the EVA are fully representative of the flow-based domains in the ED.

4.4. Cross-zonal capacities and compliance with the minimum 70% target

The Electricity Regulation introduced a minimum 70% target for capacity available for cross-zonal trade.

In 2019, ACER, regulatory authorities and the Transmission System Operators (TSOs) issued a recommendation for implementing the minimum margin available for cross-zonal trade (hereafter 'the Recommendation').[20] The Recommendation aims to ensure a harmonized implementation, monitoring and compliance assessment of the minimum 70% target. The Recommendation provides a concrete way to implement and monitor the achievement of the 70% target across the EU. In particular, the Recommendation clarifies the calculation of the margin available for cross-zonal trade (MACZT).

The Electricity Regulation allows Member States to adopt transitory measures, i.e. action plans or derogations, to gradually reach the minimum 70% target. Action plans expire by the end of 2025 and

[20] Recommendation No 01/2019 of the European Union Agency for The Cooperation of Energy Regulators of 08 August 2019.

include a gradual linear increase in cross-zonal capacity from the beginning onwards. As a result, these action plans are likely to have a limited (if any) impact on cross-zonal capacity in ERAA 2024. Depending on national regulatory authorities' decisions, derogations may apply in 2026 (or beyond).

The ERAA 2024 does not explain if any derogation to the minimum 70% target has been considered, and ACER expects that derogations will disappear once coordinated security analyses, and re-dispatching and countertrading, are fully implemented.[21] Consequently, ACER's review considers the 70% as the minimum target for all EU borders. The section focuses on the cross-border capacity on AC borders and assesses compliance with the minimum 70% target.[22, 23]

For the flow-based capacity calculation that applies to the Core capacity calculation region (CCR) in the ED and EVA, as in previous ERAA editions, ACER understands that compliance with the 70% minMACZT rule is ensured following two steps according to ERAA 2024:

1. First, net positions of all bidding zones (within and outside of the Core region) are set to zero; and
2. Second, ENTSO-E analyses for each Critical Network Element and Contingency (CNEC) whether the remaining available margin (RAM) amounts to 70% of the Fmax of each CNEC. If this condition is not met, the RAM is increased until the sum of the respective flow and reliability margin reaches a maximum of 30% of the Fmax for all CNECs.

ACER concludes that provided the above-described two-step approach is followed in a systematic and consistent manner, flow-based compliance with the minimum 70% target is correctly reflected in the flow-based calculations in the context of ERAA.

Regarding the compliance of NTC borders with the minimum 70% target, no information is provided on how the 70% rule has been ensured, except for a high-level statement on their compliance. ACER highlights that ENTSO-E needs to ensure compliance with the 70% target for all borders, starting with the ones above displayed and improve the transparency on this topic in subsequent ERAAs.

[21] The methodology is currently being implemented in most of the regions and expected to be fully implemented by the end of 2024. For more information see ACER's webpage on Redispatching and countertrading.

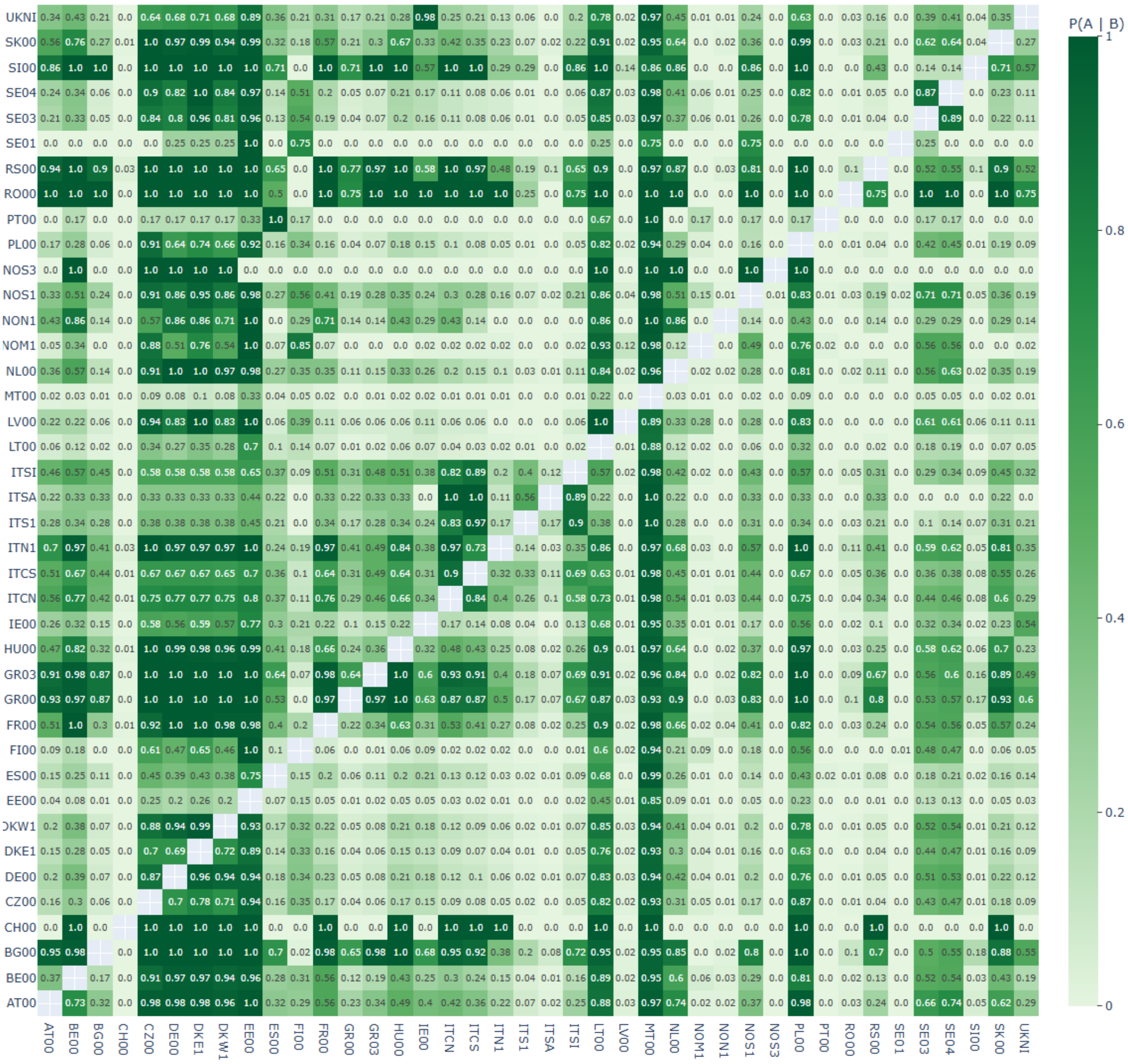
[22] The analysis of DC borders revealed full compliance in the context of ERAA 2021. For a complete review of DC borders, see ACER's ERAA 2021 Decision.

[23] For a detailed description of ACER's methodology for the assessment of NTC compliance with the 70% target, see Annex I of ACER's ERAA 2021 Decision, section 2.4.5.2.

5. Sources of adequacy concerns

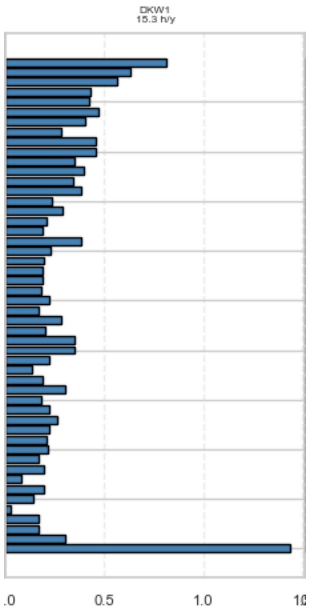
A bidding zone under scarcity, i.e. where the available power generation capacity is lower than electricity demand (with DSR activated), may be supported by a neighbouring bidding zone. However, not always cross-border cross-border exchangesare possible. Resource scarcity events may correlate among bidding zones. Peak electricity demand correlates in neighbouring bidding zones, e.g. evening peak demand during winter. In these situations, ENS may be inevitable as neighbouring bidding zones cannot support each other with cross-border power exchanges. Further in this section, peak demand, resource availability and cross-border exchanges are discussed in connection with power scarcity events.

Table 2 Correlation of resource scarcity hours among bidding zones: TY 2028



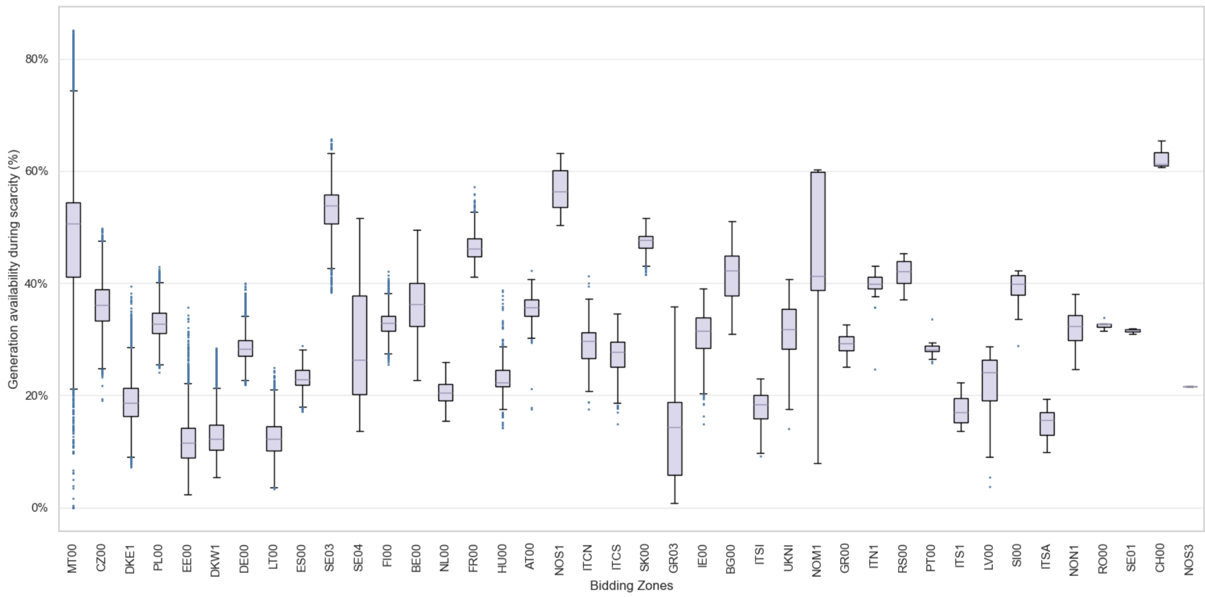
High peak demand usually correlates with power scarcity hours. But this may not always be the case in bidding zones with high-RES deployment as these bidding zones rely on electricity imports when the generation from RES is low. For example, in Denmark scarcity also occurs when demand is low as shown in **Error! Reference source not found.**

Figure 15 Native load percentile during power scarcity hours: DKW



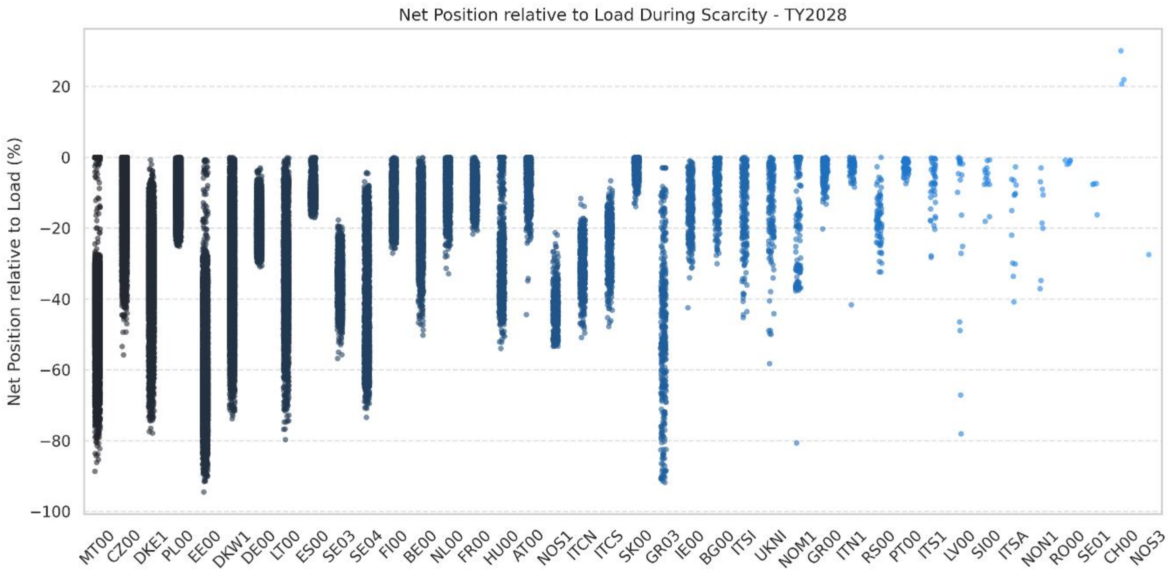
Resource availability is another aspect to look at when analyzing power scarcity events. The generation of RES cannot be shifted to scarcity events. Controllable thermal generators and partially controllable hydro power plants ensure enough power to cover high electricity demand when generation from RES is low. But this resource may not always be fully available due to unforeseen outages and prolonged periods of low generation from RES. Resource availability is depicted in Figure 16 16.

Figure 16 16 Power resource availability during scarcity hours: 2028



Electricity imports during scarcity hours correlate with simultaneous scarcity events among bidding zones. As Portugal scarcity correlates with Spain (see Table 2), imports from Spain are minimal (see Figure 1717).

Figure 1717 Imports during power scarcity relative to domestic demand: 2028



6. Appendix: Detailed tables

Table 3: Average CY demand in GWh: ERAA 2024 vs 2023 central reference scenario

TY	2028	2028	2028	2030	2030	2030
ERAA	**2023**	**2024**	**Δ**	**2023**	**2024**	**Δ**
AT	81951	84780	3.5%	89783	89000	-0.9%
BE	108229	105787	-2.3%	115488	112978	-2.2%
BG	36497	36118	-1.0%	37236	37153	-0.2%
CZ	78434	69746	-11.1%	81767	74191	-9.3%
DE	630017	621843	-1.3%	674132	661535	-1.9%
DK	50732	54303	7.0%	56962	60184	5.7%
EE	9703	9964	2.7%	9903	10526	6.3%
ES	268251	259456	-3.3%	269548	270324	0.3%
FI	102319	96296	-5.9%	109811	105611	-3.8%
FR	498954	500189	0.2%	519605	512611	-1.3%
GR	64875	61968	-4.5%	70623	66352	-6.0%
HR	17900	20219	13.0%	18000	20100	11.7%
HU	63497	53980	-15.0%	65988	60343	-8.6%
IE	42609	42430	-0.4%	45053	44918	-0.3%
IT	344128	333000	-3.2%	357456	344800	-3.5%
LT	14964	17018	13.7%	17531	18407	5.0%
LU	8766	6506	-25.8%	8939	7124	-20.3%
LV	8381	7394	-11.8%	8726	7594	-13.0%
MT	3544	3459	-2.4%	3791	3707	-2.2%
NL	150529	144168	-4.2%	161783	153388	-5.2%
PL	181038	178880	-1.2%	189232	189016	-0.1%
PT	56524	52160	-7.7%	58799	52573	-10.6%
RO	60430	57599	-4.7%	62936	60044	-4.6%
SE	185268	176031	-5.0%	203189	208592	2.7%
SI	17398	15876	-8.7%	18098	16463	-9.0%
SK	31309	30244	-3.4%	32230	31123	-3.4%
EU-27	**3116247**	**3039414**	**-2.5%**	**3286609**	**3218657**	**-2.1%**

Table 4: Differences in installed renewable capacity between ERAA 2024 and the Member State NECPs for 2030

2030	Wind			Solar		
Member State	ERAA 2024 (MW)	NECP (MW)	Difference (MW)	ERAA 2024 (MW)	NECP (MW)	Difference (MW)
AT	9000	7600	1400	13000	19000	-6000
BE	0	0	0	13610	19130	-5520
BG	2001	2500	-499	5501	6750	-1249
CZ	1274	1500	-226	12516	10100	2416
DE	143434	145000	-1566	215002	215000	2
DK	12663	13410	-747	20619	17790	2829
EE	1716	2310	-594	1570	1200	370
ES	53022	52287	735	68855	68684	171
FI	24312	10000	14312	7598	5800	1798
FR	34095	36600	-2505	40316	54000	-13684
GR	9500	10800	-1300	13537	13500	37
HR	3334	2560	774	1933	2380	-447
HU	1080	1100	-20	13090	12000	1090
IE	12000	11160	840	5500	6500	-1000
IT	28129	28140	-11	79849	79170	679
LT	6249	5900	349	6700	4100	2600
LV	1448	1310	138	1520	1600	-80
NL	25751	23200	2551	59317	25750	33567
PL	21533	21770	-237	27000	36590	-9590
PT	11797	12400	-603	15336	20800	-5464
RO	7000	7300	-300	8300	8200	100
SE	23817	23440	377	8637	9200	-563
SI	122	150	-28	4773	3450	1323
SK	712	750	-38	1725	1400	325

Source (Table 4): ACER analysis based on ENTSO-E's ERAA 2024 data and renewable energy target data from Ember's Live EU NECP tracker for Member States and for Austria, Ireland and Spain based on information provided by NRAs. The difference is calculated with the final updated NECP data as reference, where available.

Table 5. LOLE results for each bidding zone for the ED module before and after curtailment sharing (without out-of-market measures) and the EVA module

LOLE (h/year)	Target year 2026			Target year 2028			Target year 2030			Target year 2035		
	Before CS	After CS	EVA module	Before CS	After CS	EVA module	Before CS	After CS	EVA module	Before CS	After CS	EVA module
AL00	0	0	0.49	0	0	0.85	0	0	0	0	0	0
AT00	0.07	2.28	1.22	0.49	2.49	1.22	0.07	1.53	1.10	0.67	6.66	2.07
BA00	0.04	0.04	1.10	0	0	1.10	0	0	0	0	0	0
BE00	0.73	4.68	1.10	0.76	7.89	1.10	0.06	3.76	0	2.00	9.36	2.44
BG00	0.01	1.04	0.98	0	0.86	1.10	0	0.06	0	0	0	0
CH00	0.01	0.01	0.85	0.01	0.01	0.98	0	0	0	0	0	0
CZ00	3.56	8.40	1.59	15.69	19.86	2.07	9.49	10.91	0	3.36	7.42	4.03
DE00	6.33	10.79	4.32	8.39	18.79	4.03	1.86	8.21	0	2.74	9.87	3.90
DK00	0	10.84		0	21.25		0	13.38		0	13.26	
DKE1	5.52	10.64	4.32	12.00	20.96	4.27	5.29	13.34	0	6.65	12.25	2.20
DKW1	7.25	10.33	4.32	12.05	18.78	4.27	2.89	10.03	0	6.14	10.33	2.93
EE00	2.16	2.95	0	14.19	17.53	5.27	3.76	6.58	0	4.08	8.59	0
ES00	3.55	4.03	4.44	3.96	4.83	4.00	0.06	0.28	0	0.08	0.54	0.98
FI00	0.03	0.32	0	0.43	3.94	0	3.91	6.51	0	4.56	7.91	0
FR00	1.09	4.12	1.10	0.38	3.62	1.10	0.17	1.79	0	0.79	4.95	1.46
GR00	0.01	0.36	0.73	0.03	0.51	0.98	0.03	0.05	0	0	0.02	0
GR03	0.52	1.86	0.85	0.11	1.24	1.10	0.04	0.10	0	0	0.03	0
HR00	0	0	1.10	0	0.04	1.10	0	0.01	0	0	0.26	0
HU00	1.64	5.04	1.10	0.61	3.89	1.10	0.66	1.60	0	1.04	6.03	0
IE00	18.17	18.17	7.24	0.38	0.65	0	0.21	0.47	0	1.29	2.44	0.61

ISEM	0	18.36		0	0.65		0	0.55		0	2.89	
IT00	0	3.37		0	1.29		0	0.21		0	1.17	
ITCA	0	0	0.24	0	0	1.10	0	0	0	0	0	0
ITCN	0.88	2.73	0.61	0.54	1.22	1.10	0	0.20	0	0	0.77	0
ITCS	0.55	2.21	0.73	0.31	1.14	1.10	0	0.19	0	0	0.63	0
ITN1	0.13	0.67	0.61	0.01	0.21	1.10	0	0.07	0	0	0.72	0
ITS1	0.08	0.40	0.37	0.01	0.07	1.10	0	0	0	0	0	0
ITSA	0.11	0.11	0.24	0.01	0.03	1.10	0	0.06	0	0	0.28	0
ITSI	0.33	0.70	0.12	0.07	0.42	1.10	0	0.03	0	0	0.12	0
LT00	16.65	19.30	0	6.13	11.19	0	5.70	8.89	0	1.70	9.01	0
LU00	0	10.79		0	18.79		0	8.21		0	9.87	
LUG1	6.33	10.79		8.39	18.79		1.86	8.21		2.74	9.87	
LUV1	0	0		0	0.09		0	0		0	0	
LV00	0	0.01	0	0	0.04	0	0	0.01	0	0.02	0.28	0
ME00	0	0	0.73	0	0	1.10	0	0	0	0	0	0
MK00	0.02	0.02	0.73	0	0	1.10	0	0	0	0	0	0
MT00	619.56	619.50	281.81	122.06	122.06	7.78	26.26	26.25	0.12	47.52	47.52	1.49
NL00	0.37	2.40	1.22	0.18	7.79	1.46	0.06	5.44	0	0.80	6.33	1.46
NO00	0	0.59		0	2.12		0	1.86		0	3.35	
NOM1	0	0.01	0	0.06	0.46	0	0	0.91	0	0	1.78	0
NON1	0	0	0	0	0.03	0	0	0.03	0	0	0.14	0
NOS1	0.02	0.59	0	0.21	2.09	0	0	1.73	0	0	2.98	0
NOS2	0	0	0	0	0	0	0	0	0	0	0.04	0
NOS3	0	0	0	0	0	0	0	0	0	0	0.01	0
PL00	6.16	13.19	1.95	7.84	18.25	1.22	5.07	9.19	0	7.53	9.75	1.10
PT00	0.09	0.13	4.00	0.06	0.12	3.88	0	0	0	0	0	0

RO00	0	0.04	0.98	0	0.03	1.10	0	0	0	0	0.11	0
RS00	1.04	1.04	1.10	0.14	0.14	1.10	0	0	0	0	0	0
SE00	0	1.88		0	6.53		0	7.52		0	12.9 6	
SE01	0	0	0	0	0.02	0	0	1.30	0	0.04	5.08	0
SE02	0	0	0	0	0	0	0	0	0	0	0	0
SE03	0.48	1.73	0	1.38	6.22	0	1.03	7.42	0	3.00	12.7 5	0
SE04	0.01	1.73	0	0.23	5.88	0	0.85	5.64	0	3.96	9.80	0
SI00	0	0.14	1.10	0	0.18	1.10	0	0.13	0	0	2.86	0
SK00	0.07	0.85	1.22	0.07	2.91	1.10	0.81	2.54	0	1.56	4.33	3.78
TR00	0.28	0.28	1.32	0	0	0	0	0	0	7.20	7.20	8.68
UK00	0	0	0	0	0	0	0	0	0	0.46	0.46	0.61
UKNI	0.39	0.39	0	0.09	0.32	0	0.02	0.20	0	0.26	1.38	0.61

7. List of Figures

8. List of Tables