# 1 Why has ENTSO-E developed the ERAA?

In 2019 the EU adopted the Electricity Regulation[1], which updated how our electricity markets function to reflect the growing share of variable renewable energy in our system and enable flexible solutions. Part of this Regulation recognised the need for more comprehensive planning to ensure investments and regulatory decisions made today, are in line with our needs for the future. Our work today is structured by the challenge of delivering net-zero GHG emissions by 2050, a task which requires enormous international coordination and cooperation. The European Resource Adequacy Assessment (ERAA) is part of the toolbox to address this challenge, along with other ENTSO-E products such as the Ten-Year Network Development Plan and many other joint TSO actions.

With its full pan-European scope, the ERAA complements national and regional resource adequacy assessments which can give a more granular picture at a more local level. In this way, the ERAA promotes cooperation both across Europe, and between regional and national stakeholders.

The ERAA builds on deep TSO expertise and know-how gathered over many years assessing resource adequacy. This new ERAA sets a higher ambition and is a key tool for policy makers and all market actors to understand the dynamics of the future European power system and the risks and needs in meeting 24/7 secure supply to all consumers.

# 2 What does the ERAA analyse?

In short, ERAA investigates whether the electricity system has sufficient resources to meet demand in the coming decade which sets us on a net-zero pathway. The scope of the ERAA includes 37 countries explicitly modelled through 56 zones. It considers all EU member states as well as the ENTSO-E perimeter beyond EU[2]. This balance between supply and demand including various flexibility sources and grid interconnections is referred to as "resource adequacy". There are three pillars to this question, each of which entails numerous complexities:

**Supply:** the ERAA must forecast how much electricity supply is available. At its most basic, this is a measure of how much generation capacity exists; this itself is measured through an innovative economic viability assessment. However, supply may be affected by everything from weather events which impact wind and solar production, to unforeseen outages of thermal capacity. There are furthermore new technologies, especially energy storage, which will increasingly impact how we supply electricity. the ERAA builds these uncertainties into its models and crosschecks them with TSOs national estimates of future supply.

**Transmission:** Europe's integrated electricity grid means energy flows across the continent through interconnectors. Modelling the flows of electricity between generation and demand centres needs to account for the physical availability of infrastructure, as well as the functioning of our energy markets. This is an enormously complex task when one considers the scale of Europe's networks, and the many paths an electron can take between being produced and consumed. To do this, the ERAA has pioneered the application of "Flow Based Market Coupling" analyses at Continental European scale in future time frames to complement conventional techniques.

[1] Regulation (EU) 2019/943 on the Internal Market for Electricity (Electricity Regulation)
[2] With the exception of Iceland, which is not connected to the pan-European grid and thus does not have any effect on the assessment.

**Demand:** As our energy system becomes more integrated, the demand side (i.e. those who actually consume energy and the purpose of the entire energy system) will become less passive and more active. This means that they can respond to the electricity market in real-time, changing their activities in reaction to price changes and other triggers. The ERAA needs to model how this will change demand behaviour over time.

Resource adequacy assessments in future electricity systems need to embrace that the system is increasingly built on flexible and variable sources. Historic models of firm capacities and planned reserve margins are long gone. Every source to some extent has limitations and uncertainties which need to be understood and commonly assessed.

ERAA 2021 is the first step towards modelling these pillars in their entirety. It has pioneered the tools which will be used to analyse each aspect, and applied them to two target years (2025 and 2030). In future editions, this analysis will be both widened, taking in more target years, and deepened, to account for a more comprehensive set of variables.

Taken together, these three pillars mean a multitude of variables and complexities must be boiled down to answer a single question: is there a risk demand cannot be met? In the ERAA, the metric used to answer this question is called Loss of Load Expectation (LOLE). This is an estimate of how many hours supply would not meet demand, and can be checked against national reliability standards to confirm whether the adequacy situation is acceptable. It has to be noted that any LOLE value is essentially a risk assessment and an economic trade-off to be evaluated by policy makers and regulators. A non-zero LOLE value in an adequacy assessment is by no means an actual prediction of outage expectations as exceptional measures can always be taken, but flags the likelihood of extreme scarcity.

# 3 How will the ERAA be used?

The ERAA is not a concrete prediction of the future. Rather, it identifies potential vulnerabilities in our future electricity system which can be addressed proactively.

European policymakers and electricity stakeholders have a wide range of tools to address possible adequacy concerns. These can include reducing regulatory distortions, dynamic and flexible pricing, measures which empower consumers, energy storage, demand response and the development of infrastructure. Actors can also make investments in new capacity, prolong the life of old capacity, and use market mechanisms to pre-emptively respond to supply challenges. As a last resort, financial interventions like 'capacity mechanisms' may be considered, which keep power plants which would not otherwise be economical in the system, ready to provide energy at moments of peak demand.

With the core objective of climate neutrality by 2050, our energy system must manage an increasingly complex set of demands. The ERAA will be a core tool for policymakers, system operators and stakeholders to monitor the resource adequacy of the power system and to manage this transition smoothly, ensuring a secure and economical supply of electricity to customers even as more sustainable energy sources are integrated. In this way, the ERAA will support a successful energy transition.

The ERAA's strength is its ability to look across the whole system to point towards risks which would be difficult to spot when viewed solely through a local perspective.

# 4 What scenarios are considered in ERAA 2021?

ERAA 2021 assesses the target years 2025 and 2030. Expected reductions in coal and nuclear capacity over the coming years make Target Year (TY) 2025 a pivotal year to assess their impact on system adequacy. TY2030 gives a longer-term perspective, with a 10-year horizon.

The ERAA report considers several different scenarios. A scenario is the outcome of a specific set of assumptions and data, applied to a target year, and run through a set of models (methodologies) to give a picture of the future. By using these different scenarios, we can gauge the impact of certain policy, regulatory or economic measures (e.g. capacity mechanisms), and compare results found through different methodologies. The ERAA has four reference scenarios for 2025, and two for 2030:

| | CENTRAL SCENARIOS | | OTHER SCENARIOS | | PROOF OF CONCEPT |
|---|---|---|---|---|---|
| **SCENARIO NAME** | **WITHOUT CAPACITY MECHANISMS** | **WITH CAPACITY MECHANISMS** | **NATIONAL ESTIMATES** | **NATIONAL ESTIMATES WITH LOW THERMAL CAPACITY** | **FLOW-BASED** |
| **TARGET YEARS** | 2025 | | 2025, 2030 | | 2025 |
| **ECONOMIC VIABILITY ASSESSMENT** | Yes | Yes | simplified viability check | simplified viability check | Yes: without Capacity Mechanism scenario |

For 2025 especially, two scenarios give a new picture of how electricity supply will evolve. ENTSO-E has developed, and applied at the European level for the first time, a methodology to understand whether generation capacity will be economically viable in the future. This Economic Viability Assessment (EVA) is presented in scenarios with and without capacity mechanisms. In the future, the EVA will be applied to more target years, building on the learnings gathered from developing it for our 2025 scenario.

The ERAA complements the EVA with two national reference scenarios: the 'National Estimates' and 'National Estimates - Low Thermal'. These additional scenarios reflect the national estimates of TSOs with respect to installed capacities in both target years, with the latter expressing the uncertainty identified by TSOs in the commissioning and decommissioning of several assets.

The ERAA builds on the scenarios set out in the latest available Member States' National Energy and Climate Plans (NECPs). These plans set out the trajectory for Member States to achieve their national energy and climate objectives for 2030, in line with the 2018 Governance Regulation.[3] As such, these plans are aligned with the objective of a 40% reduction of GHGs by 2030; ERAA 2022 will be aligned with the EU's new objective of a 55% GHG reduction target by 2030 as per the EU Climate Law.

One of the innovative tools piloted in ERAA 2021, which will be more widely applied in future editions, is the 'Flow-Based Market Coupling". This is already increasingly applied in actual markets today. The ERAA seeks to apply these methods at wide regional scale in future time frames to mimic the dynamics of large interconnected systems and reflect critical constraints. This looks at how our electricity network and infrastructure could impact the way electricity markets trade energy across the continent. Because it must consider a significant range of variables it is an enormously complex model which has never been applied at this scale.

[3] Regulation (EU) 2018/1999

# 5 What are the findings of ERAA 2021?

ERAA 2021 shows that with planning, coordination and, where necessary, targeted measures to address adequacy concerns, Europe's power system can provide secure electricity even in the face of an unprecedented transition. Nonetheless, systems face adequacy challenges which must be managed proactively.

In the absence of action by policy makers and market players, ERAA points towards substantial adequacy challenges in 2025. With more resources in the system that operate at low marginal cost, more generation capacity may become uneconomical to operate or invest in as it cannot recover investment costs. This can be managed partially with new tools, which allow supply to react to demand more dynamically and vice versa. Some policy makers may seek to look into capacity mechanisms to ensure sufficient viable capacity and system adequacy. This is borne out by the EVA scenario for 2025 without capacity mechanisms, which shows regional risks, and the EVA scenario with existing capacity mechanisms. The latter scenario is designed to meet reliability standards in countries that apply such mechanisms.

In the longer term, i.e., target year 2030, the National Estimates scenarios show important risks on the economic viability of the assumed thermal generation fleet. The qualitative approach used in this edition for 2030 shall be considered as a first step. Refining in next ERAA editions will allow for better view on the long-term assessment. Therefore, a one-on-one quantitative comparison with the 2025 results is not valid. In addition, there will always be even more uncertainty for long term than for midterm, thus those results should be seen in a different perspective.

# 6 How does the ERAA compare to previous reports?

The ERAA builds on work previously done under the Mid-Term Adequacy Forecast (MAF), but expands and enhances it in several important ways. Most notable is the application of the Economic Viability Assessment, and the piloting of the flow-based methodology. Furthermore, the ERAA uses an expanded dataset and more advanced models than the ones which were included under MAF.

# 7 What is the implementation roadmap for the ERAA?

Given the complexity of developing a resource adequacy assessment at this scale, a stepwise approach has been taken following a roadmap for future evolution. ACER endorsed this approach in October 2020 alongside with the approval of the ERAA methodologies.[4]

As such the 2021 edition is a first step towards giving the level of analysis that ENTSO-E hopes to achieve with the ERAA. It has pioneered new tools and methodologies, including the EVA and Flow-based approach. This gives an unprecedented level of detail at the system level. The next step is to widen the application of these tools to new target years, and to factor in an increasing number of variables such as climate projections, demand side response and energy storage.

Especially in focus will be the wider application of the EVA and flow-based analysis, which together should enhance the robustness to the findings of the report. Already, hundreds of man-days and thousands of computing hours have been put towards the development of these tools.

[4] https://documents.acer.europa.eu/Official_documents/Acts_of_the_Agency/Individual%20decisions/ACER%20Decision%2024-2020%20on%20ERAA.pdf

# 8 How have stakeholders contributed to the ERAA?

ENTSO-E has sought to involve a wide range of stakeholders from the start of the ERAA process, with substantial consultation during the development of our underlying methodologies. The Electricity Coordination Group, comprising experts from EU Member States, was further instrumental to informing the production of the ERAA. They specifically advised on assumptions, fed back on data inputs and commented on preliminary results.

Looking forward, ENTSO-E aims to give stakeholders even more opportunities to input to the next ERAA reports. Firstly, a public consultation opening alongside the publication of ERAA 2021 will gather stakeholder feedback to inform work on ERAA 2022. ENTSO-E will publish its baseline assumptions and scenarios for ERAA 2022 in May 2022. This will be complemented by a dedicated webinar, allowing for stakeholder feedback. A further webinar will accompany the publication of ERAA 2022's results in November. In addition, ENTSO-E will host ad-hoc webinars on methodological features of ERAA including, for example, the economic viability assessment and how the ERAA accounts for demand side response.

To make this information accessible and transparent for stakeholders, ENTSO-E will establish a dedicated webpage to host recordings of relevant webinars, responses to stakeholder questions as well as other key information regarding the ERAA implementation process.

# 9 How does the ERAA fit with other ENTSO-E reports?

The ERAA's objective is to guide decisions on investments and regulatory interventions. This means it has a mid to long-term outlook, fitting amongst ENTSO-E's other analyses. ENTSO-E has maintained consistency on the data used between the ERAA and TYNDP, and aligned the scenarios employed. This ensures the two long term visions complement each other.