Methodological improvements of Resource Adequacy Assessments

Overview of the project

Study on behalf of the
German Federal Ministry for Economic Affairs
and Climate Action (BMWK)

The study was done in cooperation with the

PENTA
Pentalateral Energy Forum

Published on 6 February 2023

Methodological improvements of Resource Adequacy Assessments

Overview of the project

Authors

Robert Diels (r2b energy consulting)

Christian Nabe (Guidehouse)

Dmitri Perekhodtsev (Compass Lexecon)

Karoline Steinbacher (Guidehouse)

Guidehouse Germany GmbH
Albrechtstr. 10c
10117 Berlin
T +49 30 7262 1410
guidehouse.com

in cooperation with:
r2b energy consulting GmbH
Compass Lexecon

1 Introduction

Extreme prices in European electricity markets are leading to increased public attention towards measures to secure European security of electricity supply. Resource Adequacy Assessments (RAA) are providing support for policy makers by indicating the level of resource adequacy given specific assumptions and scenarios regarding the development of the electricity system for the next 10 years. More specifically, an important objective of the RAA is to inform political decision-makers whether it can be expected that a given reliability standard will be met based on current market settings and/or specific additional measures, such as capacity markets.

The Electricity Market Regulation 2019/943 requires a 10-year outlook on the development of complex national and European power systems, taking different influencing factors into account, such as weather patterns impacted by climate change. Hence, RAA methodologies are complex and often reach the limits of available data and computational power. Hence, careful choices need to be made when deciding upon a methodology for the RAA.

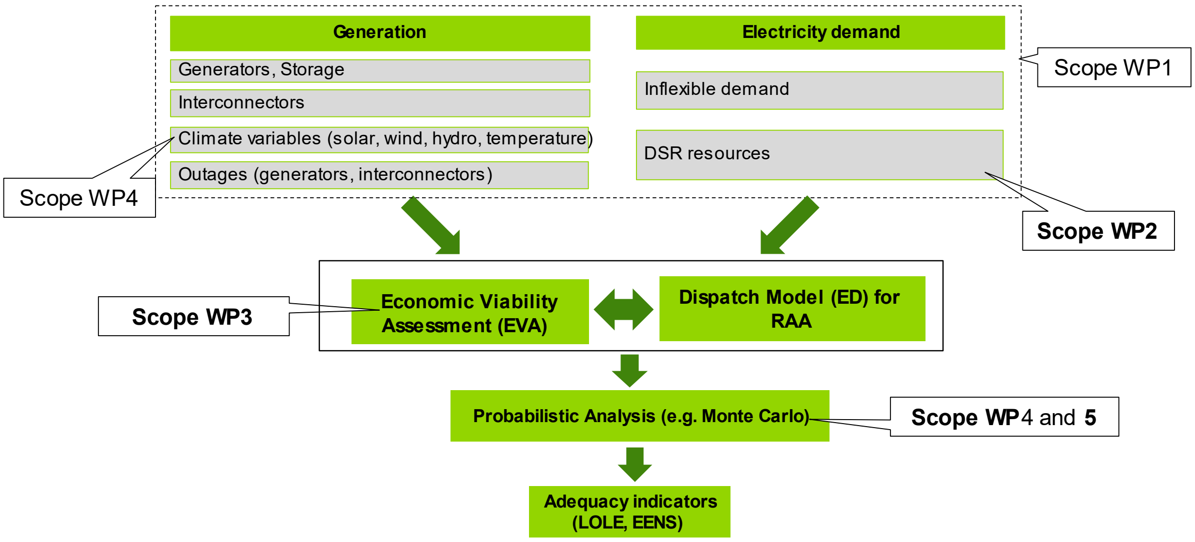
The Support Group 2 of the Pentalateral Energy Forum (Pentaforum) has been dealing with the modelling of resource adequacy since years and commissioned three RAAs in this time from the TSOs of the Penta-region. Taking one step further, the Pentaforum has decided to conduct a study on specific aspects of RAAs where possibilities for developing existing methodological approaches further were identified. The Pentaforum asked a consortium of Guidehouse Germany, Compass Lexecon and r2b to conduct this study.

This summary paper provides the main findings of the project, focusing on the following methodological aspects of RAA:

1. Sources for and quality of data being used to model RAAs (Work Package 1)
2. Methodologies to determine Demand-side Response (DSR) potentials (WP 2)
3. Approaches for economic viability assessments in RAA (WP 3),
4. Scientific assessment of the options to consider climate change (WP 4), and
5. Explanatory and analytical power of RAA regarding extreme scenarios (WP 5).

The work packages covered within this framework paper were accompanied by another work package, which contained several workshops together with experts from academia and practitioners. The main goal of the workshops was to collect additional insights and review the findings of the WP 2, 3 and 4.

The following graph shows, how the scope of the work packages integrate into the scheme of an RAA.



2 Sources for and quality of data being used to model RAAs

Background: Importance of data inputs for the outcome of RAAs

The quality of the results of any quantitative assessment is strongly determined by the underlying data inputs. High-quality RAAs, in particular, rely on a vast amount of data inputs and are consequently computationally very demanding. We address this trade-off between complexity and computational feasibility by defining minimum requirements and best-practice approaches for the choice of input variables for RAAs. This is mainly achieved by analysing recent RAA literature and examining the relevant European regulatory framework.

Scope: Clustering and recommendations for four main and 17 sub-categories

The analysis clusters the data inputs needed for RAAs into four main categories:

- Electricity demand
- Electricity supply
- Infrastructure
- Policy, regulatory and market design

These four categories are further separated into 17 sub-categories of input variables. The minimum requirements and best-practice approaches are defined on the sub-category-level. For each sub-category and each standard, we define a list of data inputs and set rough guidelines regarding their application. Based on this definition, we give a recommendation on the appropriateness of the respective standards - especially taking the trade-off between complexity and computational feasibility into account.

Main findings: Data table

The main result of the analysis is a detailed Excel workbook, listing almost 200 data inputs and the respective quality prerequisites that are necessary to fulfil (minimum standard), or even exceed (best-practice standard), the requirements set by the European regulatory framework. Furthermore, the workbook contains a detailed list of almost 50 publicly accessible sources in order to support modellers in delivering a high-quality RAA.

3 DSR potential assessment for RAA

Background: Importance of DSR for RAA and challenges

Part of the RAA is to determine the contribution of all resources from the generation-side and demand-side, energy storage as well as import and export to resource adequacy. For this purpose, it is necessary to assess the current and future potential of demand side response (DSR). Demand side response (DSR) can support the adequacy of power systems. By reducing electricity consumption of end-users through load shedding or load shifting during periods of supply scarcity, the need for dispatchable power plants, storage and transmission capacity can be reduced and thereby social welfare increased.

Although the importance of considering DSR in RAA assessments is universally recognized, an accepted methodology to assess the potential and costs of DSR in the context of RAA does not exist. The appropriate and accurate determination of the inherently heterogenous DSR options makes the development of a universal potential and cost assessment methodology difficult. Additionally, further differences exist in the activation mechanism (implicit or explicit).

However, although challenging, a comprehensive picture of available resources now and in the future is crucial. In this project, guidelines for the appropriate application of methodologies to assess a broad range of DSR potentials were developed.

Scope: Five technology-specific guidelines cover various DSR options

Based on extensive literature research, expert interviews and two workshops, this project has assessed existing methodologies for DSR potential and cost assessment. This assessment led to the development of six guidelines covering a wide range of technologies, theoretical, technical and achievable potential. These guidelines cover the DSR potential assessment for the following technologies:

- flexibility options in energy-intensive industries
- cross-sectional technologies in industry and commercial, trade and services
- Power-to-X – Electric vehicles
- Power-to-X – Power-to-Gas
- cross-sectional technologies in households
- behind-the-meter battery storages

Data availability is the bottleneck for DSR assessments, so the guidelines prescribe alternative routes for assessment based on selected methodologies. The alternatives depend on data availability, available resources, and the required accuracy. This approach helps to allocate available resources in the most efficient way.

Main findings: Flow charts to describe the DSR potential assessment approach

The main result of the work package is the clear and easy to follow representation of the DSR potential assessment approaches via flow charts, where each of the six technology-specific guidelines contains one flow chart. The flow charts provide step-by-step guidance on how to perform the assessment. They are structured in four steps to describe the assessment from theoretical, to technical, to achievable and, finally, to the economic potential. Furthermore, within each step possible data sources for input parameters are highlighted, necessary data processing steps as well as interim and final results. Also, for each step alternative assessment approaches are clearly distinguished, if applicable for a certain technology.

Other findings

Further insights from this work package cover the modelling choices for in-the-market and out-of-the-market DSR resources. For some potentials (e. g. cross-sectional technologies in households) assignments to three distinct categories are possible (out of the market, e. g. for resources following time-of-use tariffs; in the spot market, for resources directly reacting to spot prices; In other markets, e. g. due to participation in direct load control schemes). The choice depends on the assumptions of how business models for DSR work in the future and is mostly relevant for smaller DSR potentials (like cross sectional technologies in commerce and households) which are yet untapped. These assumptions lead to quite different results of the RAA. Hence, assumptions on the future need to be made carefully to neither over- nor underestimate the influence of these potentials or treated as sensitivities.

Moreover, in our analysis we found that the six developed guidelines do not differ widely, but the availability of data or the cost and time to acquire data will be decisive. Our guidelines show how to consider DSR even if data availability is limited to make at least a conservative estimation. The cooperation with aggregators is an effective way of data acquisition since this task is in the core of the business. A possible bias needs to be considered. Different data sources should be used to cross-check results (plausibility).

The current gas and electricity price crisis might be a good opportunity to evaluate price elasticity of demand. The discussion in our workshops led to diverse views on whether a loss in comfort will be acceptable for consumers or if consumers insist on the availability of their household DSR options such as EVs at any cost.

4 Economic Viability Assessment methodologies for Resource Adequacy Assessments

Background: The role of Economic Viability Assessment as part of RAA
In the context of RAAs, an Economic Viability Assessment (EVA) shall provide an endogenous assessment of the economic decisions of operators of capacity resources to maintain, retire, mothball, extend or new-build capacities. Such decisions may have a significant impact on the resource adequacy over the time horizon of 10 years as applied for RAAs in the EU.

EVA assesses the decision to enter or exit capacities in the electricity system, depending on revenues from wholesale markets, from ancillary service and balancing markets, as well as from capacity markets where they exist, from subsidies and other sources which allow to cover the fixed costs, O&M and, where applicable, the costs of (re-)investment.

Scope: Methodological options and approaches of EVA

The objective of this work package is to review and assess the two methodological options for applying the Economic Viability Assessment (an EVA), which the methodology for the European Resource Adequacy Assessment (ERAA) as approved by ACER contains in Article 6 para 2:

- **Individual EVA approach.** The economic viability of individual assets is an explicit assessment of revenues and costs by asset. The revenues from the wholesale market, ancillary services, from outside of the electricity sector and subsidies, and, where applicable, the from capacity mechanisms are directly assessed and stacked for different capacity resources. The entry, exit and mothballing decisions are then assessed for each capacity resource based on the comparison between market revenues and fixed and variable costs and accounting for the risk.

- **Cost minimisation EVA approach**. The second option is to take a system perspective and to implement EVA based on a minimisation of total system costs. In this case, the entry and exit decisions are assessed simultaneously for all capacity resources, all bidding zones by minimising the discounted costs of investment and operation of the entire power system.

To that end, several workshops with academia and industry experts were held in order to identify main drivers of (de-)investment decisions in practice and how they could be implemented in the modelling setting of an EVA. The workshops revealed a number of specificities of the market participants' decisions to enter or exit capacity in the market. In particular, this discussion highlighted potential differences in the drivers of the entry and exist decisions between conventional baseload plants and flexibility resources, such as peakload power plants, DSR and storage.

Operators of conventional plants seem in principle more risk-averse, especially as investment decisions consider a rather long timeframe. Flexibility resources, on the other hand, can have a more risk-seeking profile, as they can be mobilised at comparably lower investment cost and faster. These different profiles have to be appropriately reflected in EVA.

Main findings: The choice of EVA approach is driven by the unavoidable modelling simplifications

We conclude that in principle, the two approaches would likely yield the same results when using the same inputs and if unlimited computational capacity was available. The relative strengths and weaknesses of the two approaches only manifest because each approach **requires simplifications** that tend to allocate the available computational capacity to different elements of the EVA:

- The individual EVA focuses explicitly on an accurate estimation of the market prices and revenues, making sure the economic dispatch model used for the price estimation properly accounts for the generation constraints and calibrating the results on the historical market and price outcomes. However, the complexity on the investment element of the model may require simplifications regarding interdependencies between resource types, markets and regions.
- The cost minimisation approach, in turn, allows for considering all interactions and combinations of entering and exiting capacity types across all bidding zones considered in the assessment. However, it may require simplifications e.g. of the chronology and intertemporal unit commitment constraints, which may result in a reduced accuracy of the modelling of the wholesale and balancing markets.

A combination of two approaches could provide a potential solution to the computational limitations of each of the approach, as was suggested by the academic workshop participants. In particular, the capacity equilibrium resulting from the cost minimisation EVA could be used as a starting point for the viability assessment of the EVA of capacity resources.

5 Scientific assessment of the options to consider climate change

Background: Accounting for climate change in the RAA

The Electricity Regulation 2019/943 requires to account for the climate change impact on resource adequacy in RAA. The ENTSO-E methodology for the RAA as approved by ACER contains three options to take climate change into account:

- rely on a best forecast of future climate projection
- weight climate years to reflect their likelihood of occurrence (taking future climate projection into account)
- rely at most on the 30 most recent historical climatic years included in the PECD

This work package examines and compares these options, highlighting their appropriateness and effectiveness by reviewing research papers and methodologies applied by TSOs to reflect climate change in adequacy studies.

Scope: Literature review, expert workshop and assessment of the options

We have performed a literature review and found that climate change is expected to have an impact on power systems, on both the supply and demand of electricity, as well as on adequacy:

- **Impact on power demand and power plants efficiency**: Over the ten-year timeframe of the RAA, the temperature increase is expected to decrease heating demand, increase cooling demand and to decrease efficiency of thermal generation.
- **Impact on hydro production and thermal plant availability**: Expected changes in precipitation and evaporation decrease hydropower potential and increase the risk of the shutdowns of thermal power plants located along rivers during severe droughts.
- **Impact on variable renewables production**: The literature suggests both potential increases and decreases of wind production depending on regions and studies. Studies also suggest a negligible to small positive effects on PV from changes in irradiance while temperature increase lowers efficiency.

Studies that analyse the impact of climate change on adequacy conclude that climate change would decrease LOLE in cold countries, mainly due to a reduction of heating demand during winter. Conversely, warm countries could see their LOLE increasing due to a higher expected cooling demand over summer.

A workshop with academic experts specialising in the studies of the climate change and their impact on the power systems was held to provide further details on the expected impact of the climate change on adequacy and on the ranges of approaches to address this in the context of the RAA.

Main findings: Forecast of future climate projection preferred, with weighted climate years as suitable alternative

Based on the literature review and on the inputs obtained in the workshop, we assessed the three ACER's options with respect to three criteria: (i) accuracy; (ii) complexity; and (iii) compatibility with other studies.

Overall and albeit more complex, the first option which consists in relying on a projection of future climate is the most accurate and preferable option for including climate change in RAA, as it allows to assess the climate change effects on all climate variables used as inputs into power market modelling (temperatures, wind speeds, precipitation and solar radiation) in a consistent way. The complex modelling involved can also be justified by the flexibility of this approach to apply and test in RAA different climate evolution scenarios.

We consider the second option in its generalised formulation, consisting in an adjustment of the historical data to account for the historical climate trends. This option can be quite accurate over the timeframe of the RAA of ten years over which the climate change effect is not expected to be very significant, assuming that historical trends are representative for the next ten years. However, this option may lack consistency between all climate variables obtained through extrapolation.

The third option which consists in relying on the 30 most recent historical climatic years without any refinement or trend correction is the simplest option out of the three since it does not require any additional modelling. However, the last 30 years contain the historical climate trend and using these data directly would most likely result in underestimating the effect of the climate change over the next ten years.

6 Explanatory and analytical power of RAA regarding extreme scenarios

Background: RAA-models as potential tool to analyse extreme events

The aim of WP 5 is to analyse, whether (adapted) RAA-Tools are suitable to assess extreme events. The basis for the analysis is formed by two different legislations, the Electricity Market Regulation 2019/943 (EMR) and the Risk Preparedness Regulation 2019/941 (RPR). While these Regulations not explicitly refer to each other, overlaps regarding methodological approaches do occur in practice, because both require modelling of the electricity system to analyse whether demand can be covered at the electricity markets under specific circumstances. In the context of the EMR in the form of Resource Adequacy Assessments (RAA) and according to the RPR in the form of analysing extreme events and short-term and seasonal adequacy assessments (STSAA).

Scope: Three different approaches to assess extreme events identified

Based on an analysis of the EMR and RPR, we identified three different approaches to assess such extreme events using (adapted) RAA-tools which differ regarding their probabilistic degree:

(1) The more general full probabilistic approach (e.g., central reference scenarios (CRS) in RAA), which aims at an unconditional probability and includes random variables with their respective probability distributions.
(2) The more specific conditional probabilistic approach (e.g., sensitivities to CRS in RAA), where the analysis is stochastic by means of availability of resources and climatic conditions, but aims at a conditional probability, i.e., assumes that the extreme event is happening (condition).
(3) The more straight forward deterministic approach (e.g., specific analyses winter 2022/23), where also the usually stochastic / probabilistic variables are set deterministically.

The suitability of the application of one of the three approaches depends on the nature, the likelihood of occurrence and the predictability of the impact of the respective extreme event.

Main findings: RAA-tools in principle suitable, but adaptions and different interpretation of KPIs potentially needed

In principle RAA-models used under the EMR generally seem to be suitable to assess all kinds of extreme events. One the one hand, analysing extreme events by the full probabilistic approach has the difficulty, that an extreme event is only one unlikely outcome out of numerous alternatives or may even not be covered by the input data at all. If it is covered by the input data, detailed information on an event may be derived in a full probabilistic approach with a deep-dive into the event by performing a ‘critical hour analysis’. On the other hand, using adapted RAA-tools under the condition that an extreme event is happening within the more specific conditional probabilistic approach, or the more straight forward deterministic approach are more suitable for an explicit analysis of extreme events and enable the direct calculation of meaningful KPI expressing the severity of the analysed event (e.g., Loss of Load, Energy not served).

Using RAA-Tools to analyse extreme events may therefore need some adaptations. It may be reasonable to skip the economic viability assessment when assessing unexpected or very rarely occurring extreme events. Furthermore, deterministic elements may have to be applied to focus on these events in order to extract and analyse extreme events in detail. That, in turn, also affects the KPIs being used in RAA (usually LOLE and EENS), which have to be interpreted differently when assessing extreme events in this way. KPIs derived from such adapted RAA-tools are no longer expected values, but rather express the severity of the analysed event assuming it occurs.

However, it remains unclear from a legislative perspective whether such adapted RAA-tools for focused analysis of extreme events fall within the scope of the legislative framework of the EMR or the RPR. More regulatory clarity seems needed here, as the regulatory framework of the analysis may also have an impact on the measures being applicable to manage the different impacts that such extreme events may have on the system.