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**Short-term and Seasonal Adequacy Assessments  
Methodology in accordance with Article 8 of the  
REGULATION (EU) 2019/941 of 5 June 2019 on risk-  
preparedness in the electricity sector and repealing  
Directive 2005/89/EC**

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Date: 6 January 2020

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ENTSO-E, considering the following,

### Whereas

This document is developed by the European Network of Transmission System Operators for Electricity (hereafter referred to as “ENTSO-E”) regarding a Short-term and Seasonal Adequacy Assessment Methodology (hereafter referred to as the “Methodology”) in accordance with Article 8 of Regulation (EU) 2019/941 of the European Parliament and Council on risk-preparedness in the electricity sector (hereafter referred to as “RPR”) and repealing Directive 2005/89/EC.

- (1) The Methodology takes into account the general principles and goals set forth in the RPR as well as the EU legal framework, in particular:
  - a. Regulation (EU) 2019/943 of the European Parliament and of the Council of 5 June 2019 on the internal market for electricity (hereafter referred to as “Electricity Regulation”);
  - b. Directive (EU) 2019/944 of the European Parliament and of the Council of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU (hereafter referred to as “Electricity Directive”);
  - c. Commission Regulation (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation, (hereafter referred to as “SO GL”);
  - d. Commission Regulation (EU) 2015/1222 of 24 July 2015 establishing a guideline on capacity allocation and congestion management (hereafter referred to as “CACM”);
  - e. Commission Regulation (EU) 2017/2196 of 24 November 2017 establishing a network code on electricity emergency and restoration (hereafter referred to as “Network code on emergency and restoration”); and
  - f. Council Directive 2008/114/EC of 8 December 2008 on the identification and designation of European critical infrastructures and the assessment of the need to improve their protection.
- (2) The goal of the RPR is to ensure the implementation of the most effective and efficient process for risk preparedness within the Union. The application of a common approach—through this Methodology—in Short-term and Seasonal adequacy assessments, whether carried out at national, regional or Union level, is key to achieve this goal.
- (3) Article 8 of the RPR sets the legal basis and requirements for the Methodology developed by ENTSO-E. It shall be based on a common probabilistic adequacy assessment approach considering uncertainties of inputs—availabilities of transmission capacities, availabilities of power plants, variability of demand (in particular, peak demands depending on weather conditions), severe weather conditions and renewable energy production—and it shall cover the probability of occurrence of an electricity crisis and of a simultaneous electricity crisis at a national, regional or Union level.
- (4) Upon its adoption, ENTSO-E will use this Methodology—as required by Article 9 of the RPR—to issue seasonal adequacy assessments in the form of winter and summer outlooks with the purpose of alerting Member States, transmission system operators and all other relevant stakeholders of adequacy-related risks that might occur in the following six months. Regional Coordination Centres (RCCs) will use this Methodology—as required by Article 9 of the RPR—to perform week-ahead to at least day-ahead adequacy assessments to continuously monitor adequacy.
- (5) TSOs should also apply this Methodology as a reference when carrying out any other type of short-term adequacy assessment, especially the week-ahead to at least day-ahead generation adequacy forecasts provided for in SO GL.

The purpose of the short-term and seasonal adequacy assessment is to assess if expected (or planned) availabilities of supply and transmission infrastructure are sufficient to ensure adequacy in short time-frames and under which circumstances a risk may exist. This continuous intra-year monitoring is necessary to ensure that mitigating actions could be taken to respond to changing operational conditions, weather patterns and occurred contingencies. When the assessments show they can pose a risk for adequacy, dedicated measures can be taken to mitigate the risk, for instance planned generation or network outages can be rescheduled.

Seasonal adequacy assessments provide a link<sup>1</sup> between one-year-ahead resource adequacy assessments, performed through the European Resource Adequacy Assessment (ERAA), set in Chapter IV of the Electricity Regulation, and the short-term adequacy assessment performed according to this Methodology. The Methodology for the seasonal adequacy assessments builds on the ERAA methodology whereas short-term Adequacy has a reduced uncertainty due to the availability of weather forecasts.

The Methodology shall be adopted by ENTSO-E for seasonal adequacy assessments (Winter Outlooks and Summer Outlooks) and potential month-ahead assessments, while RCCs are to adopt this Methodology to perform short-term adequacy assessments.

- (6) The ERAA methodology developed under the Electricity Regulation has the same foundation as this Methodology.
- (7) The outcomes from the pan-European adequacy assessment can be refined in regional and national studies, which can incorporate a higher granularity and local sensitivities, while complying with the Methodology.
- (8) The methodology for the day-ahead timeframe should be established to respect the requirements of Article 21 "Assistance for active power procedure" and Article 22 "Manual demand disconnection procedure" of the Commission Regulation (EU) 2017/2196 of 24 November 2017 establishing a network code on electricity emergency and restoration (hereafter referred to as "Network code on emergency and restoration").
- (9) In case major contingencies or input updates (e.g., rescheduling of maintenance) are foreseen after the seasonal adequacy assessments (Winter Outlooks and Summer Outlooks) and in case ENTSO-E, RCC(s) or TSO(s) estimate this could cause an adequacy risk, a month-ahead adequacy assessment will be performed.
- (10) In conclusion, the Methodology contributes to the general objectives of the RPR to the benefit of all market participants and final electricity consumers.

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<sup>1</sup> High-level information flow is presented in Annex II.

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ENTSO-E SUBMITS THE FOLLOWING METHODOLOGY TO ACER:

### **Article 1**

#### **Subject matter and scope**

1. The Methodology has been developed in accordance with Article 8 of the RPR. The Annexes constitute an integral part of the Methodology and shall be read together with its provisions.
2. The Methodology shall establish the process to assess seasonal and short-term adequacy, namely month-ahead, week-ahead to at least day-ahead.
3. The Methodology shall cover the following uncertainties:
  - a. the probability of outages of transmission elements;
  - b. the probability of unplanned outages of power generation units;
  - c. variability of demand, in particular peaks depending on weather conditions;
  - d. variability of energy production from renewable energy sources;
  - e. variability of weather conditions and their impact on demand and supply.
4. The Methodology shall enable adequacy assessments to estimate the probability of the occurrence of an electricity crisis and a simultaneous electricity crisis defined in Article 2 of RPR.
5. In accordance with Article 9(1) of the RPR, the Methodology shall also serve as a reference method, without prejudice to innovation going beyond it, for all other short-term adequacy assessments, whether it would be on national, regional or Union level. Regional and national adequacy assessments may use higher granularity and a more detailed and different representation of data where necessary.
6. In accordance with Article 9(1) of the RPR, all short-term adequacy assessments, whether performed at national, regional or Union level shall be carried out in accordance with the Methodology. The outcomes of the pan-European adequacy assessments shall provide coherent inputs for regional and national studies, that can be more detailed by incorporating a higher granularity, using more detailed datasets or performing additional analyses, without being detrimental to the compliance with the Methodology.
7. The Methodology shall not limit the geographical scope of the analysis. Adequacy assessments performed by ENTSO-E and RCCs will cover at least a region composed of ENTSO-E members and other TSOs for which Articles 81, 106 and 107 of SO GL apply. ENTSO-E and RCCs (itself and its' members) shall continuously engage operators of other tightly interconnected systems to establish and foster cooperation. If tightly interconnected neighbouring regions commit for cooperation on adequacy assessments, they should be modelled with the same level of detail as the core analysed systems. Otherwise, contribution to pan-European adequacy of those systems would be considered with the assumption of ENTSO-E's members having interconnections with those systems. Hereafter, these systems will be referred to as 'non-explicitly modelled systems'.

### **Article 2**

#### **Definitions and interpretation**

1. For the purposes of this Methodology, terms used in this document shall have the meaning of the definitions included in Articles 2 of the RPR, Electricity Regulation, Electricity Directive and SO GL.
2. The following additional definitions shall also apply:
  - a. 'Planned Outage' means a state of an asset when it is not available in the power system but this outage was planned in advance, including maintenance, mothballing and any other non-availabilities known in advance.
  - b. 'Unplanned Outage' (also called Forced Outage) means a state of an asset when it is not available in the system and this outage was not planned.

- c. ‘Unit Commitment and Economic Dispatch (UCED) means a mathematical optimisation model, which determines the commitment schedule of supply and demand units and their level of dispatch, in order to meet demand for every time-step of the modelling horizon. The objective function of the problem minimizes system cost, including Expected Energy Not Served (EENS), while satisfying the operational constraints of the power system.
- d. ‘Non-explicitly modelled systems’ means electric systems which do not provide direct data for adequacy assessments, but are tightly interconnected with any member of ENTSO-E or any other electric system for which Articles 81, 106 and 107 of SO GL apply. Contribution of those systems to the pan-European adequacy assessment shall be considered using assumptions (e.g., market behaviour) provided by the TSO(s) to which they connect.
- e. ‘Explicitly modelled systems’ means electric systems which are an integral part of the European power system and for which Articles 81, 106 and 107 of SO GL apply.
- f. ‘Market-based resource’ means any supply or demand resource available in the system complying with market rules and commercial agreements.
- g. ‘Non-market measure’ means any supply or demand-side measure deviating from market rules or commercial agreements, the purpose of which is to mitigate an electricity crisis.
- h. ‘Study zone’ means smallest geographical part of electrical system for which adequacy is being assessed.
- i. ‘Study perimeter’ means whole electrical system modelled in adequacy assessment. This means the set of all study zones.
- j. ‘Loss of Load Expectation’ (LOLE) means, in a given zone during a given time period, the expected number of hours during which resources are insufficient to meet the demand needs.
- k. ‘Loss of Load Probability’ (LOLP) means, in a given zone and during a given time period, the probability that resources would be insufficient to meet the demand needs.
- l. ‘Expected Energy Not Served’ (EENS) means, in a given zone and during a given time period, the energy which is expected not to be supplied due to insufficient resources to meet demand needs.
- m. ‘Adequacy probability metric’ (APM) means, in a given study zone and in a given time period, the probability of resources being sufficient to cover demand with supply. The sum of APM and LOLP yields 100%.
- n. ‘Normal conditions’ means operational conditions, such as weather conditions, generation availabilities and network availabilities, resulting in typical operational situations. It relates generally to the set of operational conditions which results in fiftieth percentile (50th percentile) of a supply margin probability distribution.
- o. ‘Stressed (severe) conditions’ means operational conditions, such as weather conditions, generation availabilities and network availabilities, resulting in severe operational situations. It relates generally to the set of operational conditions which results in fifth percentile (5th percentile) of a supply margin probability distribution.
- p. ‘Supply margin’ means , in a given zone and during a given time period, the available supply in excess of the foreseen demand, considering all resources dispatched, all resources not dispatched but available to be dispatched, and all resources available in other study zones, subject to given transmission capacity constraints.
3. In this methodology, unless the context requires otherwise:
- the table of contents and headings are inserted for convenience only and do not affect the interpretation of this Methodology; and

– any reference to legislation, regulations, directive, order, instrument, code or any other enactment shall include any modification, extension or re-enactment of it then in force.

### **Article 3** **Seasonal Adequacy Assessments**

1. All seasonal adequacy assessments, whether carried out on national, regional or Union level, shall be based on the probabilistic method described in Annex I.
2. This Article refers to European assessments led by ENTSO-E. Any other seasonal adequacy assessments, whether carried out on national or regional level, performed by other bodies than ENTSO-E shall adopt the framework set out in this Article to the extent which is relevant<sup>2</sup>.
3. In accordance with Article 9(2) of the RPR, ENTSO-E may delegate tasks relating to the adequacy assessments to RCCs.
4. Winter Season shall include at least the core period between 1 December and 31 March, and can be extended up to the period between 1 November and 30 April.
5. Summer Season shall include at least the core period between 1 June and 30 September, and can be extended up to the period between 1 May and 31 October.
6. Seasonal Adequacy Assessment consists in adequacy assessments of winter and summer seasons. Their core assessment periods defined in Article 3(4) Article 3(5) are minimum requirements, and extended periods may be assessed if specific and relevant risks are expected, such as unexpected high maintenance, very low hydro reservoir levels, etc. The concerned TSO(s) shall justify, using factual information, the need for extension of seasonal period to ENTSO-E.
7. Seasonal adequacy assessments shall be based on any relevant metrics, including Loss of Load Expectation (LOLE), Loss of Load Probability (LOLP) and Expected Energy Not Served (EENS).
8. The seasonal adequacy assessment shall consist of the following steps:
  - a. Run of Monte Carlo probabilistic assessment with UCED model, as defined in Annex I;
  - b. Spatial analysis on seasonal basis to detect zones with adequacy risk, meaning hours with probability that part of demand might be not supplied (LOLP is higher than 0);
  - c. Temporal analysis on weekly basis to detect periods with adequacy risk;
  - d. Focused analysis of adequacy in zones and weeks with high identified risks of electricity crisis or simultaneous electricity crisis, in agreement with Article 8(1) of the RPR, in case the related probability of occurrence has a value deemed to make these situations relevant to be analysed in detail;
  - e. Sensitivity analysis to assess possible measures to prevent or mitigate adequacy risks, in particular with respect to the use of non-market measures to mitigate an electricity crisis. The approach in developing such sensitivities shall take into consideration compliance with market rules, in agreement with the principles set up in Article 16 of the RPR.
9. Results of seasonal adequacy assessments shall be published, at the latest, by the first day of the concerned assessment period.
10. In case major contingencies or input updates (e.g., rescheduling of maintenance) are foreseen after the seasonal adequacy assessment and in case ENTSO-E or TSO(s) estimate this could cause an adequacy risk, a month-ahead adequacy assessment will be performed.

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<sup>2</sup> i.e. common methodology but possible different approaches for reporting and result disclosure

## **Article 4**

### **Short-term Adequacy Assessments**

1. All short-term adequacy assessments, whether carried on national, regional or Union level, shall be based on the probabilistic method described in Annex I of the Methodology and in accordance with Article 9(1) of RPR, considering uncertainties of demand, supply and transmission availabilities. Complementary deterministic assessments triggered or based on pre-defined scenarios and compliant with the methodology might be performed to validate risk and assess countermeasures to mitigate detected problems, including use of network models (when these models will be available).
2. Short-term adequacy assessments shall be carried out for month-ahead and week-ahead to at least day-ahead. ENTSO-E shall lead the month-ahead assessments with possible delegation to RCCs; RCCs shall lead the week-ahead to at least day-ahead assessments in cooperation with ENTSO-E. Any other short-term adequacy assessments, whether carried out on national or regional level, performed by other bodies than ENTSO-E or RCCs shall apply the framework set in the present article to the extent relevant.

## **Article 5**

### **Month-ahead Adequacy Assessments**

1. A month-ahead adequacy assessment shall be performed following a request made by a TSO or RCC, as soon as one of the below situations occurs:
  - a. The supply or network availability changes significantly compared to the assumptions used in the seasonal adequacy assessment and ENTSO-E or TSO(s) estimate this could cause an adequacy risk;
  - b. An extraordinary low supply and/or an extraordinary low transmission availability is foreseen during the interseason period.
2. Month-ahead adequacy assessments shall be requested by the concerned TSO(s) or RCC to ENTSO-E. Relevant national authorities (e.g., national regulating authorities, ministries) may request a month-ahead assessment to ENTSO-E via their national TSO. All requests shall be submitted together with justification as well as input information to be considered in the adequacy assessment.
3. ENTSO-E shall inform all TSOs about month-ahead adequacy assessment requests and collect all necessary data to perform such studies. TSOs shall promptly contribute to the collection of data requested. ENTSO-E can delegate month-ahead adequacy to RCC.
4. Month-ahead adequacy assessments can be implemented either as a partial re-run of seasonal adequacy assessment after updating specific data, or as a run of a series of week-ahead adequacy assessments considering month-ahead data.

## **Article 6**

### **Week-ahead to at least day-ahead Adequacy Assessments**

1. Week-ahead to at least day-ahead adequacy assessments shall be based on TSOs' estimates and on ENTSO-E's databases described in Annex I. It shall consider all relevant fact-based information as required in Annex I, as well as operational security limits between study zones.
2. TSOs shall consider the most up-to-date weather forecast available and deliver a range of likely demand, wind and PV infeed and availability of transmission capacities and outages. RCCs shall use this range of likely demand, wind and PV infeed together with the historical distribution of the same variables and construct a correlated representative set of demand, wind and PV infeed data for adequacy assessments. Hydro inflows are considered deterministic in the week ahead time frame.
3. Week-ahead to at least day-ahead adequacy assessment shall consider the most up-to-date information available about planned outages and the uncertainty of unplanned outages of supply and transmission availabilities.

4. Week-ahead to at least day-ahead adequacy is assessed using hourly APMs for each zone. Furthermore, other supporting metrics are used such as EENS, LOLE to be consistent with requirements set in Articles 105 and 107 of SO GL.

### **Article 7**

#### **Data collection and preparation**

1. The data collection for adequacy assessment processes shall be centrally coordinated by ENTSO-E, respectively by RCCs for their mandated and delegated tasks. It shall consider the most recent available information and follow data collection framework principles that are developed in dedicated working groups and constantly updated to follow technological developments and modelling capabilities: i) Data collection guidelines are provided to each national TSO to guarantee a coherent data collection process. Such guidelines are constantly updated to incorporate new inputs required under technological developments or changes under improved modelling frameworks. They specify the assumptions that each TSO shall use when providing data and guarantee a standardized data preparation process, ensuring that datasets are built on consistent, transparent and common assumptions.; ii) The data requested from TSOs is input for coordinated prepared data at expert groups (e.g. demand input data as a basis for the preparation of climate-dependent demand times-series per study zone)
2. Collected data is subject to consistency checks and further preparation performed by the body in charge of the concerned adequacy assessment. In case the short-term or seasonal adequacy assessment is performed considering neighbouring power systems, datasets from pan-European databases shall be used whenever available. This is especially relevant for regional and national adequacy assessments, for which data of neighbouring systems is available in the pan-European databases employed in pan-European adequacy assessments.
3. Consistent data sets shall be used in pan-European, regional and national adequacy assessments. Data shall be shared between ENTSO-E and RCCs, allowing utilization of data from one assessment to another when no updated data is available (e.g. reuse of seasonal data for short term assessments).
4. In exceptional cases, ENTSO-E may also formally request data from external market parties such as national regulating authorities, distribution system operators, national electricity market operators, power plant/asset owners or operators and other relevant stakeholders, should this data be i) missing from the TSO data collection, and ii) be needed to set up the appropriate scenarios or assumptions for the short-term/seasonal adequacy assessment methodology.

### **Article 8**

#### **Result Analysis**

1. Result analysis is a process of quantitative result investigation of an adequacy assessment. This shall be carried out by the responsible body of the assessment, ahead of the study report defined in Article 9(1) of the Methodology.
2. Quantitative adequacy result investigation is based on probabilistic metrics. It shall be complemented by additional analysis examining patterns of adequacy risks, where such risks are identified.
3. Result analysis shall include quantitative simultaneous adequacy risk investigation, including the assessment of their probability.

### **Article 9**

#### **Result dissemination**

1. The results of the adequacy assessment shall be presented in a report. The report shall be transparently listing both inputs and outputs, being an exhaustive, informative and reader-friendly document. It shall consist of a high-level summary and dedicated technical appendices.
2. In accordance with Article 9(2) of the RPR, ENTSO-E shall publish the results of the seasonal adequacy assessment, at the latest, by the first day of the concerned assessment period on a designated ENTSO-E

web-page and present them at a meeting of the Electricity Coordination Group, which may make recommendations where appropriate.

3. In case an adequacy risk is identified in a national, regional or Union level adequacy assessment, all relevant bodies<sup>3</sup> shall be immediately notified. In accordance with Article 105(3) of SO GL, each TSO is responsible for notifying relevant national authorities about adequacy risks identified within its control area in any adequacy assessment—whether on a national, regional or Union level. Furthermore, in accordance with Article 105(4) of SO GL, each TSO shall notify all TSOs via ENTSO-E if they identify any adequacy risk in their national assessments in either their own control area or in a neighbouring control area. The neighbouring TSOs are then responsible to inform their own national regulating authorities promptly about the identified adequacy risks, if such risks have been identified in their control area. For avoidance of doubt, TSOs shall communicate with neighbouring national regulating authorities only via the neighbouring TSOs.
4. Where risks are identified in the ENTSO-E pan-European seasonal adequacy assessment, the Electricity Coordination Group and relevant parties shall be informed as soon as the seasonal adequacy assessment results are available, to support preparation of mitigation measures.
5. TSOs shall initiate coordination of internal (within the TSO community) and external (with relevant stakeholders outside the TSO community) communication via ENTSO-E in case an adequacy risk is identified in any of the adequacy assessments. When a critical grid situation is identified, a communication process shall be triggered by a concerned TSO or RCC. In particular, for the case of regional week-ahead adequacy assessments, article 81 of SO GL requires that RCCs, when detecting situations where a lack of adequacy is expected, must deliver the results, together with the actions it proposes to reduce risks, to the TSOs of the capacity calculation region, including proposals for remedial actions that allow the increase of cross-border exchanges. In the particular case of control area adequacy analysis, articles 105 and 107 of SO GL require that TSOs, when detecting the absence of adequacy within its control area, must notify the absence to its regulatory authority or, when explicitly foreseen in national law, another competent authority and, where applicable, any affected party. TSOs shall provide an analysis of the causes of the absence of adequacy and propose mitigating actions.

## **Article 10**

### **Publication and implementation of the methodology**

1. ENTSO-E shall publish the final version of the Methodology on its website without undue delay after ACER's approval or amendment, in accordance with Article 8(4) of the RPR.
2. ENTSO-E, RCCs and TSOs shall implement the Methodology one year after its approval. Each short-term and seasonal adequacy assessment shall include a description of the Methodology implementation status.
3. Following the approval of the Methodology, updates can be triggered at any time pursuant to Article 8(5) of the RPR.

## **Article 11**

### **Language**

4. The reference language for this Methodology shall be English.

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<sup>3</sup> The notification shall be carried out in accordance with Article 14(1) of Regulation (EU) 2019/941 and include TSOs and NRAs of neighbouring systems.

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## **Annex I**

### **Short-term and Seasonal Adequacy Assessment—Description**

#### **I. General**

1. Short-term and seasonal adequacy assessments aim to monitor whether available supply and transmission are sufficient to cover demand under various weather and operational conditions on a temporal horizon of up to six months ahead.
2. The adequacy assessment shall be based on an UCED model.
3. The UCED model shall consider the inter-zonal and inter-temporal (e.g., between 2 successive time-steps) correlation of variables and the characteristics of the assessed geographical perimeter.
4. The model shall be implemented with a resolution no greater than hourly, i.e., a daily model is not permissible.
5. Uncertainty is represented through a number of scenarios of different random unplanned outages of generators and/or transmission elements and different weather conditions. The climate data, related to hydro inflows, irradiation, wind speed and temperature shall consider weather forecasts when available. The inter-zonal and inter-temporal correlation of climate parameters shall be ensured.
6. Adequacy assessments consist of base case calculations, which, in case of adequacy issues, must be supplemented by sensitivity cases to assess countermeasures to mitigate adequacy risk. Additional sensitivity cases might be defined as well.
7. Adequacy assessments consider three major pillars: demand (including demand side response, system reserve capacity requirements and other system requirements), supply (e.g., generation, storage units) and grid representation which connects demand and supply in different zones. ENTSO-E shall coordinate dedicated pan-European databases containing the latest information on demand, supply, grid and weather conditions. These databases, collected by ENTSO-E from TSOs or service providers, aim to increase consistency of inputs across Europe.
8. All resources shall be considered if they are market-based. Any non-market measures shall not be considered in the base case calculations, but shall be assessed in sensitivity assessments as possible measures to prevent or mitigate adequacy risks, in case such a risk is detected.
9. Availabilities of supply and interconnectors shall consider planned outages. Unplanned outages of supply and interconnectors shall be considered in a probabilistic manner and should be based on unplanned outage rates and mean time to repair, derived from statistics.
10. Any information used in the adequacy assessments shall be based on the most recent available data. This includes planned outages, weather forecast or any other relevant data used in the assessment. The data collection follows a standardized process, where methodologies for data preparation embrace supply, demand, transmission capacity and any other data estimation.

#### **II. Probabilistic Assessment**

11. The short-term and seasonal adequacy assessments shall use a probabilistic methodology to assess adequacy for the concerned period. The methodology shall follow a Monte Carlo method to reflect the variability of weather as well as the randomness of supply and transmission unplanned outages.
12. Monte Carlo simulations shall be built combining the weather-dependent variables and random outages. Each weather scenario consists of a realistic combination of demand (accounting for temperature dependency), wind, solar and hydro inflow time-series. From each weather scenario, the relevant time period is selected, i.e., the season, month or week under consideration. Each set of weather scenarios is further associated with a relatively large number of random unplanned outage samples, that is, randomly assigning unplanned outage patterns for thermal units and interconnections (HVDC and relevant HVAC, consistent with the methodology used for capacity calculation in accordance with the CACM Regulation).

The convolution of weather scenario, from which only the relevant time period is retained, and number of random unplanned outage patterns defines the final number of Monte Carlo scenarios analysed.

13. The weather scenarios are built onto historical data and employing weather forecasts whenever these are available for the concerned adequacy assessment period. When the weather forecasts are available, the uncertainty of weather forecasts shall be considered by constructing a dataset covering the uncertainty range and taking into account the probability of each value. The uncertainty range is large when the assessment period is far away (e.g., seasonal adequacy assessment) and decreases as the operation time frame approaches.
14. The convergence of the Monte Carlo method shall be assessed by the coefficient of variation ( $\alpha$ ) of the *EENS* adequacy metric. It describes the volatility of the *EENS* adequacy metric in the Monte Carlo assessment. Coefficient of variation is defined by the equation below:

$$\alpha_N = \frac{\sqrt{\text{Var}[EENS_N]}}{EENS_N}$$

where *EENS* is the expectation estimate of *ENS* over *N* number of Monte Carlo samples, i.e.,  $EENS_N = \frac{\sum_{i=1}^N ENS_i}{N}$ ,  $i = 1 \dots N$ ; and  $\text{Var}[EENS]$  is the variance of the expectation estimate, i.e.,  $\text{Var}[EENS_N] = \frac{\text{Var}[ENS]}{N}$ .

15. A stopping criterion for the probabilistic assessment is enforced, under a sufficiently large number of Monte Carlo samples, by comparing the relative increment of  $\alpha$  with a given threshold value  $\Theta$ . In particular, for *N* sufficiently large, if:

$$\frac{|\alpha_N - \alpha_{N-1}|}{\alpha_{N-1}} \leq \Theta$$

increasing the number of Monte Carlo samples *N* for adequacy assessment would not increase the level of accuracy considerably: consequently, the Monte Carlo analysis can be stopped.

16. To indicate the reliability of adequacy assessment results, these parameters shall be reported along the results:
  - a. the number of analysed Monte Carlo samples *N*;
  - b. the values of  $\alpha$  as a function of the number of Monte Carlo samples *N*.

### III. Demand

17. Demand shall be derived based on likely weather conditions and shall comply with temporal and spatial resolution of the assessment. If short-term weather forecasts for the study zones are available at the moment of assessment, these shall be used to estimate demand.
18. Demand side response availabilities shall be used in the assessment if they are available in the concerned period. This concerns elasticity of demand (e.g., demand reduction and demand postponement as reaction to market signals). It is defined as the maximum demand reductions along with the maximum duration of such reduction; and maximum demand postponement, along with the maximum postponement period. Demand side response which is a non-market measure (i.e., interruptible demand) shall be disregarded in base case assessment. Demand side response which provides system services shall be disregarded as well. In case Demand side response provides balancing reserves, it shall be disregarded if it provides Frequency Containment Reserves (FCR) or Frequency Restoration Reserves (FRR) but considered if it provides Replacement Reserves (RR).
19. Need for energy exports to non-explicitly modelled systems shall only be considered if exports must be delivered even in case of supply scarcity in the assessed region or if it would have long-term impact on

energy availability in the assessed region. Need for energy exports to non-explicitly modelled systems shall be modelled as additional demand.

20. Need for reserve capacity (balancing reserves) shall be defined in accordance to SO GL, Articles 153 to 159 and clearly identified in the input dataset.
21. Need for ancillary services other than balancing reserves shall be defined in accordance to SO GL, Articles 108 and 109 and clearly identified in the input dataset. It shall correspond to the active power (expressed in MW) impacted by the ancillary service need.

#### **IV. Supply**

22. Supply shall be considered as all available generation units and storage units in the assessed system and expected available imports from non-explicitly modelled neighbouring countries.
23. Generation supply shall be defined in terms of net generating capacity.
24. Storage units shall be defined in terms of net discharge capacity, net charging capacity, storage capacity and charge-discharge cycle efficiency rate.
25. Generation and storage supply units may be aggregated based on technology. Individual supply units should be modelled when relevant and feasible—especially for large thermal generation units. As a best practice, national and regional studies should perform adequacy assessments, considering same or more detailed yet consistent supply representation compared to the pan-European adequacy assessments.
26. Available imports from non-explicitly modelled neighbouring countries shall be defined in terms of expected availability of energy imports. Estimation by TSO can be based on existing contracts, historical records, information on generation availability, demand estimations and transmission availabilities, or any other reliable available information
27. Any supply not available in the energy market shall be disregarded. This includes but is not limited to supply units or part of supply units which are contracted or expected to provide any ancillary services. Concerning balancing reserves services (which are part of ancillary services), FCR and FRR shall be deducted from the available supply in the adequacy assessment, as they shall cover imbalances and frequency deviations within the time resolution of seconds to minutes. RR shall be considered as available capacity contributing to supply in the adequacy assessment.
28. Any supply planned outage which affects supply availability shall be accounted for.
29. Supply unplanned outages shall be considered as a random sample of the UCED model, considering unplanned outage rates (probabilities of such events) and mean time to repair as a reliability parameter input of the model. These parameters shall be derived based on historical outages in the assessed power system. Uniform unplanned outage rates and mean time to repair per technology can be used. Nevertheless, unplanned outage rates matching supply granularity in assessment should be used whenever possible. Furthermore, local unplanned outage rates and mean time to repair by study zone should be used when reliable information is available.
30. Weather-dependent supply (e.g., wind, solar, hydro) shall reflect modelled weather conditions to build a data set that is spatially and temporally consistent across Europe.
31. Any seasonal variation impacting the supply availabilities (e.g., Combined Heat Power plant availabilities in different seasons) shall be considered. It shall be modelled as hourly time series of the available supply.
32. Any energy constraints shall be considered. This is especially relevant for hydro generation modelling. The energy constraints include, but are not limited to, energy inflows, reservoir size and minimum energy release requirements.

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## V. Grid

33. The grid is divided into zones which are modelled as copper plates, neglecting technical constraints inside each study zone.
34. The minimum requirement for study zone granularity shall be the smallest level between country, bidding zone and control area. Control areas might be merged for the assessment to single bidding zone or country in case there are no structural transmission limitations between control areas of this bidding zone or country and there is no requirement to perform the assessment at control area level.
35. The grid is represented as a set of modelled interconnections between study zones. Modelled interconnections represent Net Transfer Capacity zone coupling or Flow-Based zone coupling. In one adequacy assessment a combination of zone coupling methods might be used—some zones might be coupled through Net Transfer Capacity zone coupling and others through Flow-Based zone coupling. Grid representation shall be evolutive, considering market coupling of each specific region, in line with CACM.
36. Upper bound values to exchange constraints are maximum exchange capacity constraints in case of Net Transfer Capacity zone coupling or Remaining Available Margin constraints in case of Flow-Based zone coupling, in line with CACM. Exchange constraints may be complemented with total zone position constraints (net import or net export) in case it is mandatory to ensure safe system operations, as is a common practice in the market coupling due to external constraints pursuant to Article 23 of CACM. Temporal granularity on how such upper bound values are provided should take into account variability in time (e.g., winter and summer, working day and not working day, day and night, etc.).
37. The impact of weather conditions shall be considered when estimating exchange constraints. Weather forecast shall be used when available.
38. If any seasonal pattern of exchange constraints is historically observed, those shall be considered when estimating exchange constraints.
39. Any known planned outage which affects exchange constraints shall be accounted for.
40. Unplanned outages of grid elements shall be considered as a random sample of the UCED model, considering probabilities of such events as an input of the model and mean time to repair. These parameters shall be derived based on historical outages in the assessed power system. Cross-border and internal grid element outage impacts on exchange constraints shall be considered.

## Annex II High-level information flow scheme

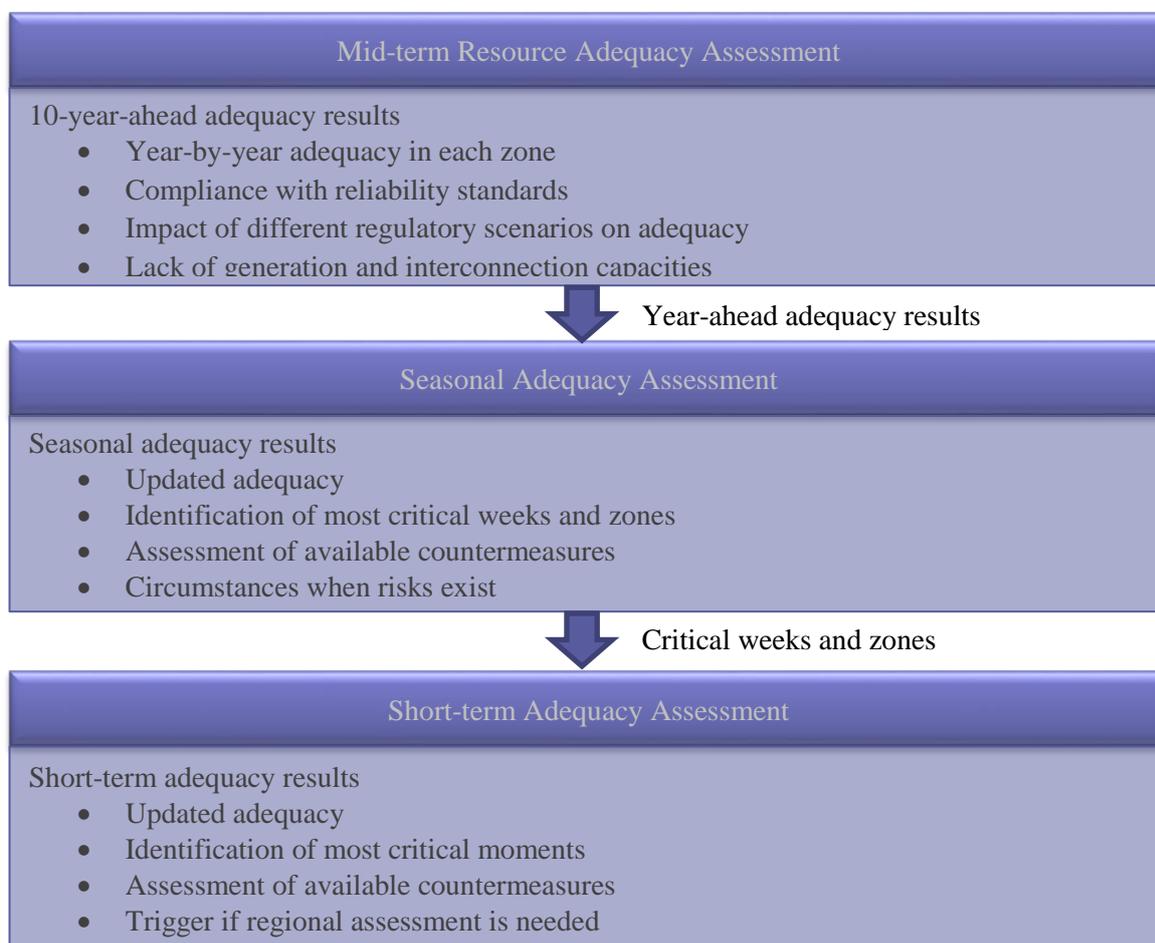


Figure 1: Information flow between adequacy assessments in different time horizons

### Annex III High-level Business process diagram

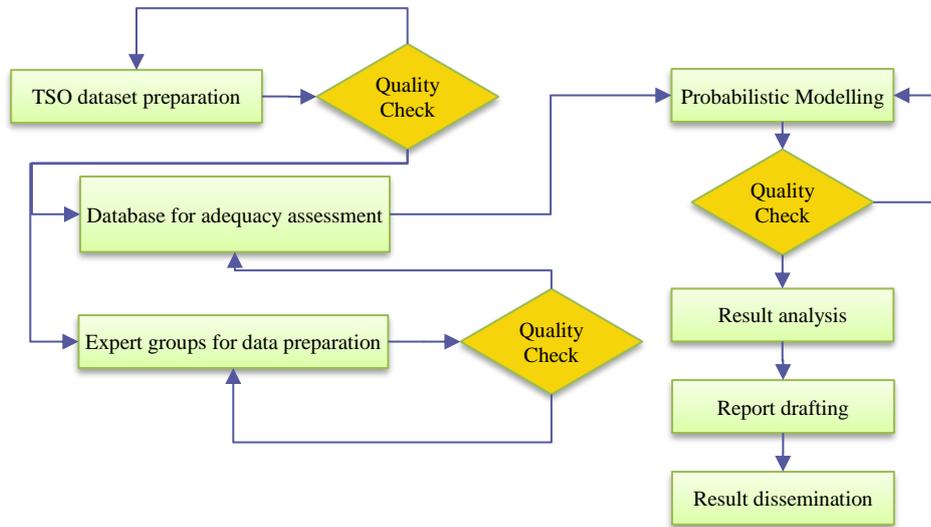


Figure 2: Principal process for adequacy assessments

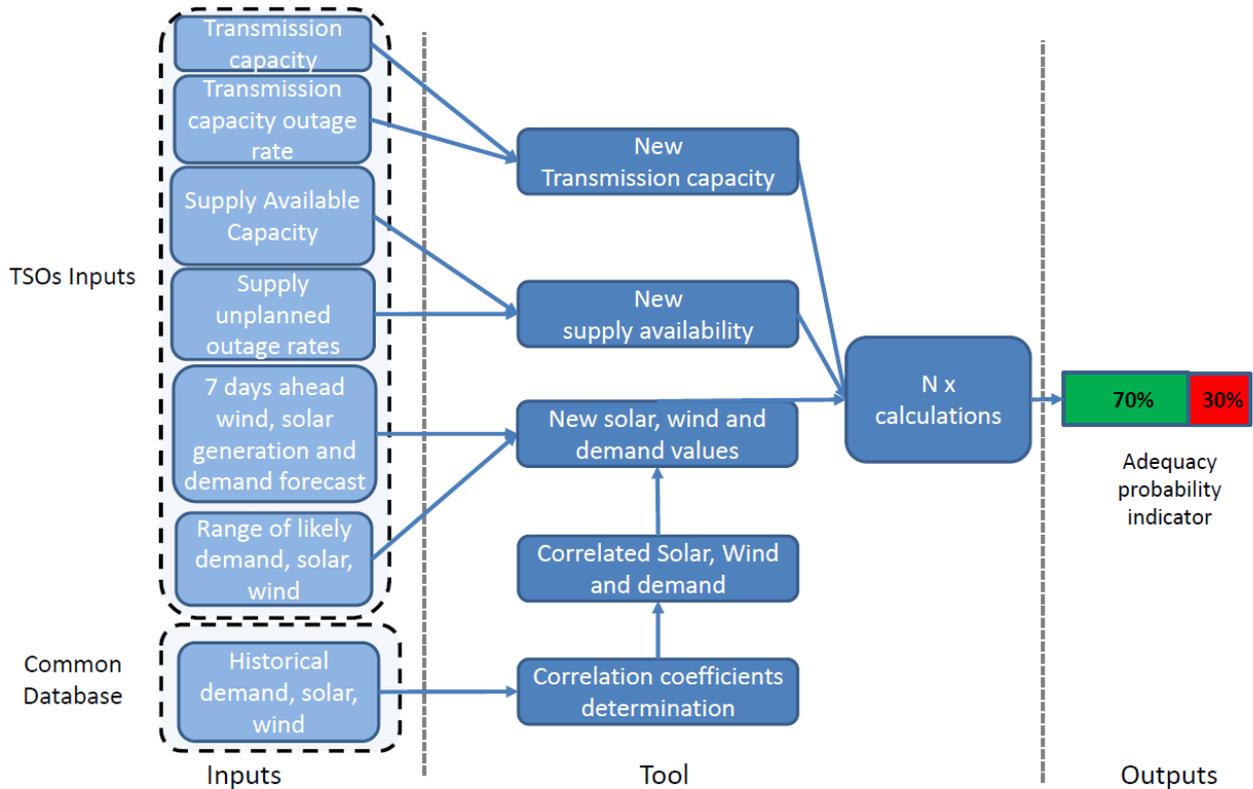


Figure 3: Foreseen week-ahead short-term adequacy assessment process