6 January 2020

Short-term and Seasonal Adequacy Assessments Methodology –

Explanatory note

(supplements the Methodology document for information and clarification purposes)

Disclaimer
This explanatory document is submitted by ENTSO-E to ACER and all Stakeholders for information and clarification purposes only accompanying the "Short-term and Seasonal Adequacy Assessment Methodology in accordance with Article 8 of the Regulation (EU) 2019/941 of 5 June 2019 on risk-preparedness in the electricity sector".

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Contents

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I Introduction

The short-term and seasonal adequacy assessment requirements are set in Article 8 of Regulation (EU) 2019/941. Focussing on study horizons of less than 1 year ahead, it can be clearly separated from the European Resource Adequacy Assessment (ERAA). Latter covers study horizons 1-10 year-ahead, assessing the impact of the system development trends on adequacy, including a change in the generation capacity mix, a change of demand patterns, network developments, etc.

Beside their specific purpose, one additional benefit of each study (mid-term, seasonal and short-term) is that findings in one assessment are transferred to the next, shorter timeframe assessment. This information transfer raises awareness of data preparation quality importance and suggests where analysis of adequacy deserves more attention. However, each assessment product performs a fully updated analysis, using the latest available data.

Decarbonization of the electricity sector and massive integration of variable RES leads to an increased need for regional cooperation on adequacy assessment and risk preparedness to prevent and manage electricity crises. The seasonal adequacy assessment supports decision making by stakeholders (MSs, NRAs, EC, ACER, Market Operators, etc.) – who try to mitigate risks for the coming season – and bridges the gap between the mid-term resource adequacy and short-term adequacy assessments. Short-term adequacy assessments are also gaining importance, especially considering the pace of renewable energy expansion.

The risk-preparedness regulation (RPR) of the clean energy for all Europeans package stretches goals and framework of both short-term and seasonal adequacy assessments. For these assessments, there is a need for a common approach to the way possible adequacy-related problems are detected. This document supplements the Methodology document with details on the method that is used to assess adequacy and an explanation of concepts that are used in the Methodology.

In this document, if not explicitly mentioned, the same descriptions apply for both seasonal and short-term adequacy assessments.

II Short-term and seasonal adequacy assessments—general adequacy assessments context

Short-term and seasonal adequacy assessments have a different purpose than medium to long-term European resource adequacy assessment (from year-ahead to several years ahead). The use of a common methodology for the medium to long-term resource adequacy assessment is prescribed in the Electricity Regulation 2019/943. It shall ensure that Member State decisions on possible investment needs are made on a transparent and commonly agreed basis. Short-term and seasonal adequacy assessments are used to detect possible adequacy related problems in short timeframes, namely seasonal (six months ahead), month-ahead, week-ahead to at least day-ahead adequacy assessments. These assessments shall first ensure risk awareness for all relevant stakeholders and support system operation by identifying what the adequacy risks are and when these risks exist. It can also support system operation planning to mitigate those risks (e.g. maintenance planning). The same methodological principles may be applied for short-term and seasonal adequacy assessments. However, the latter assessment deals with higher uncertainty compared to the short-term adequacy assessment. This uncertainty is namely related, but not limited, to weather conditions.

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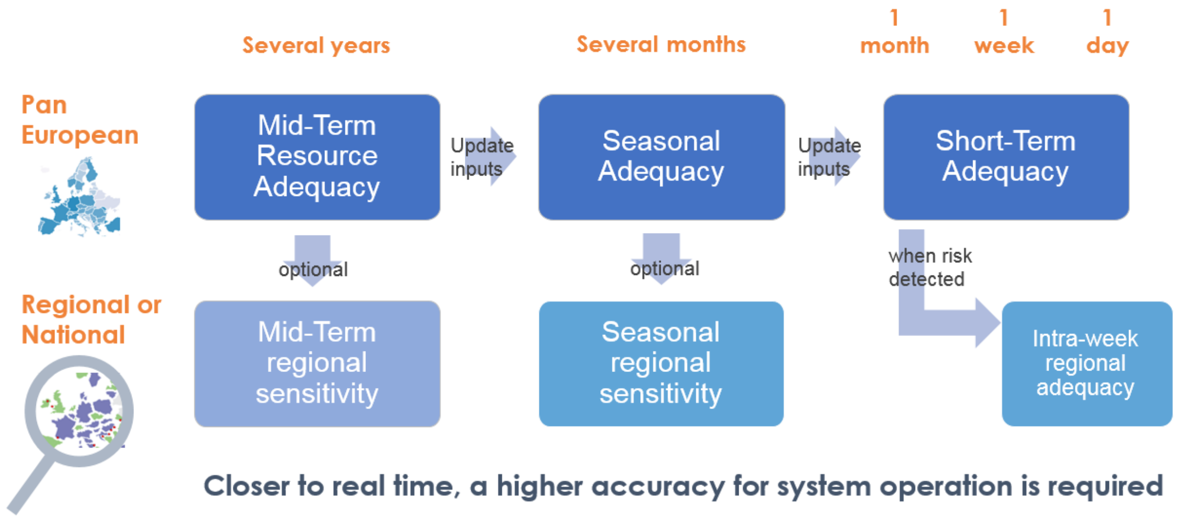

Figure 1. Overview of pan-European Adequacy Studies

Several-years-ahead resource adequacy assessments require a large set of data as probabilistic inputs, while in infra-week adequacy assessments some inputs can be forecasted (e.g. wind, temperature) and therefore modelled with lower uncertainty but still by using a probabilistic approach.

Seasonal adequacy assessments bridge mid-term and short-term adequacy assessments, providing insight on potential periods of adequacy risks using a wide range of climatic scenarios.

Short-term adequacy assessments, namely week-ahead to at least day-ahead, refine the inputs based on forecasts, thus dramatically reducing the uncertainty. They can include ad-hoc regional studies with detailed network models to validate risks and evaluate counter-measures to mitigate adequacy problems detected in the pan-European phase of the assessment. This provides insight into the circumstances and contingencies under which risks would be credible. Furthermore, TSOs can trigger a regional assessment when internal congestions can be anticipated, even if no risk is detected.

Month-ahead adequacy assessments may be performed on TSO request if resource availability changes significantly compared to the corresponding seasonal assessment. The month-ahead adequacy assessment is classified as a short-term adequacy assessment and is performed in between seasonal and week-ahead adequacy assessments. Very often in this timeframe, information does not change significantly compared with the seasonal adequacy assessment. Therefore, the latest seasonal adequacy assessment already covers the risks of most possible resource availability changes. Furthermore, the uncertainty of the month–ahead study compared with the seasonal adequacy assessment does not decrease as is the case with week-ahead adequacy assessments. On the other hand, in some rare occasions, a significant change of resource availability might occur. An example of such a change could be an extension of the planned outage of a big generation unit or of an interconnection which will prevent this unit to come back to operation. Such a significant change of resource availability may have an impact on adequacy in a timeframe larger than the week-ahead timeframe. Therefore, month-ahead adequacy assessments might be performed if TSOs estimate that the situation has changed significantly compared to the seasonal adequacy assessment and if TSOs estimate this impact to go beyond the week-ahead horizon.

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III Scope of Adequacy Studies

1. Geographical perimeter

The geographical perimeter covers all ENTSO-E members and engages neighbouring regions to participate in the adequacy studies. The minimum requirement for geographical granularity is the minimum size between country, bidding zones and control area.

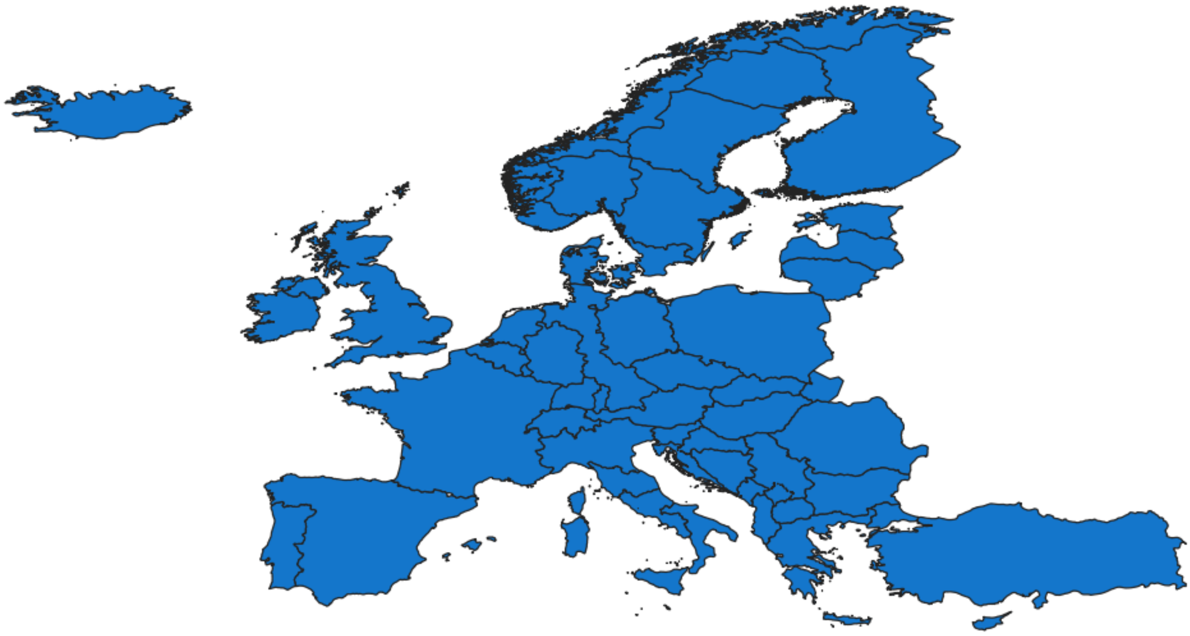

Figure 2 Geographic perimeter of short-term and seasonal adequacy assessments (status December 2019)

Furthermore, ENTSO-E endeavours to establish and foster cooperation between tightly interconnected systems' operators. If those regions commit to cooperation on adequacy assessments, they should be modelled in the same detail as the core analysed systems. Otherwise, contribution to pan-European adequacy of those systems will be considered with the assumption of ENTSO-E's members having interconnections with those systems. These systems are referred to as non-explicitly modelled systems.

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Explanation

Model element	Modelled Zone	Non-explicitly modelled system
Demand	Yes	No
Resources	Yes	No
Outages (forced and planned)	Yes	No
National Balance	Yes – result of resources, outages and demand balance	Yes – neighbouring TSO assumption
Interconnections	Yes	Yes – neighbouring TSO assumption
Impact of weather variability	Yes	No

2. Temporal scope

At least hourly time-steps shall be used in all studies covered by this methodology.

Short-term adequacy assessments
The week-ahead adequacy assessment is performed every day and covers the 7 following days. This assessment also includes the day-ahead timeframe as required by regulation.

Seasonal adequacy assessments
The seasonal adequacy assessment covers at least one season as described in the Methodology – the period between 1 December and 31 March for winter adequacy assessments; and the period between 1 June and 31 September for summer adequacy assessments.

The abovementioned study periods shall be considered as minimum requirements to be respected for all seasons. It corresponds to the experienced risk periods for the security of supply in Europe. ENTSO-E does not exclude specific assessments in earlier or later weeks if there would be a potential risk.

IV Adequacy calculations general approach

The objective of adequacy assessments is to monitor if available supply and transmission capacities are enough to cover demand under various conditions; and if not, adequacy assessment attempts to identify location, moment, impact and specific sources of adequacy risks.

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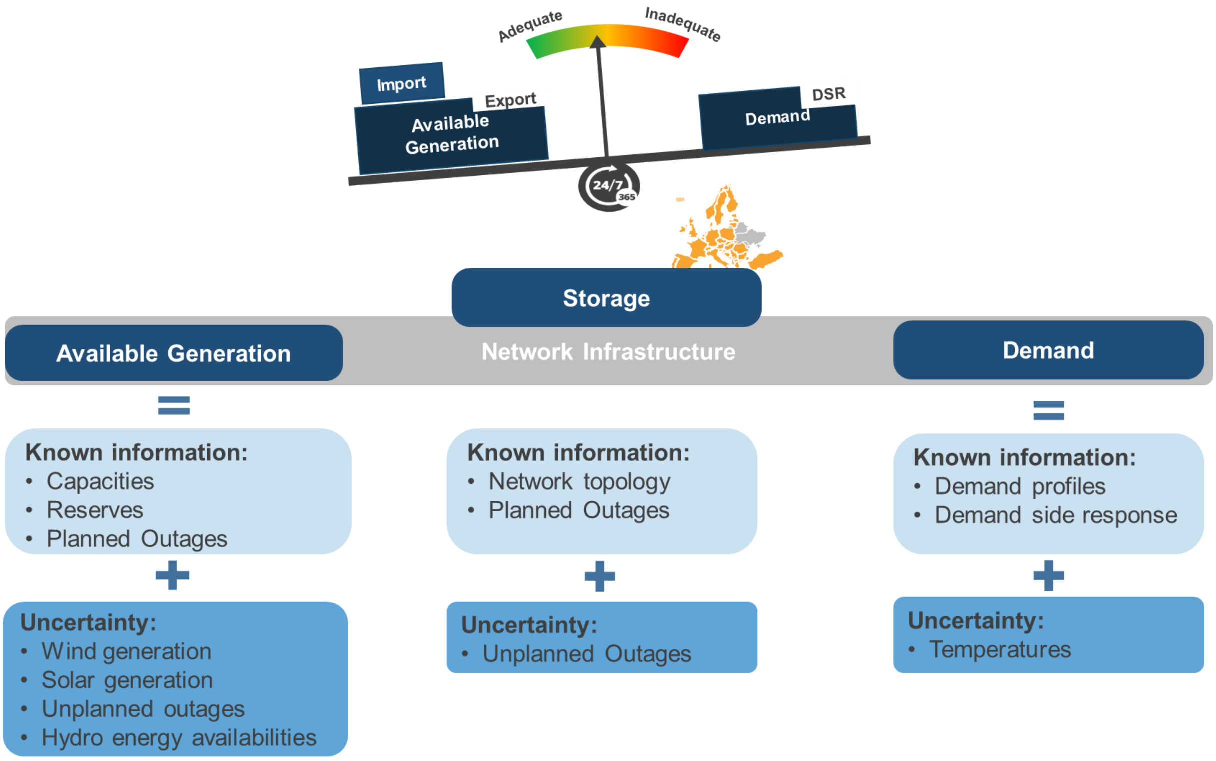


Figure 3: General Adequacy methodology

Using the well proven Monte Carlo probabilistic approach, a set of possible scenarios for each variable is constructed to assess adequacy risks under various conditions for the analysed timeframe. For all these scenarios, at least hourly calculations are performed for the whole geographical scope.

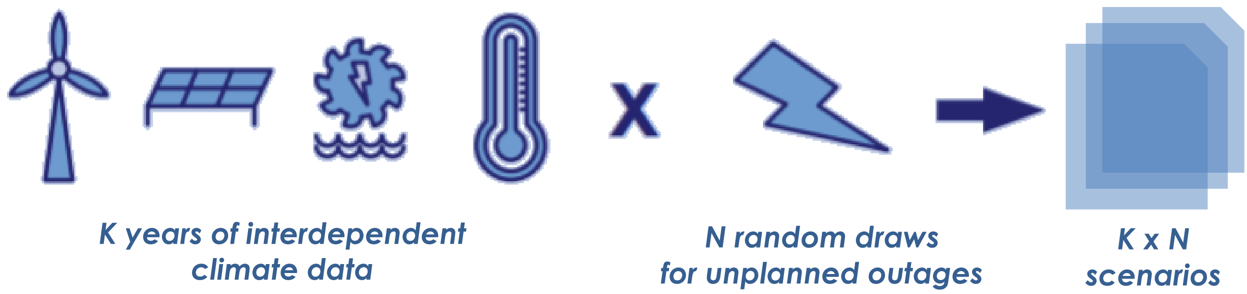


Figure 4: building set of scenarios

Scenarios are constructed ensuring that all variables are correlated (interdependent) in time and space. Correlation is ensured by the analysis of historical weather conditions and variable input statistical data (e.g. demand). To ensure highest quality of data used in assessments, they are prepared by experts working within dedicated teams. A pan-European Climate Data base maintained by ENTSO-E and assures a high data quality and consistency across Europe.

Resources shall be considered if they are market-based. Any non-market resources, such as strategic reserves, shall be disregarded in the base case calculations. They may only be considered as a possible remedial action in sensitivity study.

The dispatch price (which sets a merit order) is determined on common fuel and CO_2 price assumptions that are used as best estimates. These prices are future prices of CO_2 and fuels, or when such prices do not exist, the latest statistical information is taken (e.g. nuclear fuel prices).

Supply and interconnector availability consider scheduled maintenances and other known outages. Unplanned outages of supply and interconnectors (HVDC and HVAC) are considered in a probabilistic manner using historical data, and consider both probability of outage and repair time. While modelling unplanned outages of supply units and HVDC interconnectors is rather straightforward, modelling unplanned outages of HVAC interconnections is more complicated, as these interconnectors do not represent physical cross-border interconnectors but rather represent a physical capability to exchange energy between two systems.

V Model Elements

Adequacy models are built using three major pillars: demand (including demand-side response and system reserve requirements), supply (e.g. generation, storage units) and a grid representation which connects demand and supply in different zones. Additionally, climate data are used to address uncertainties of these three major pillars.

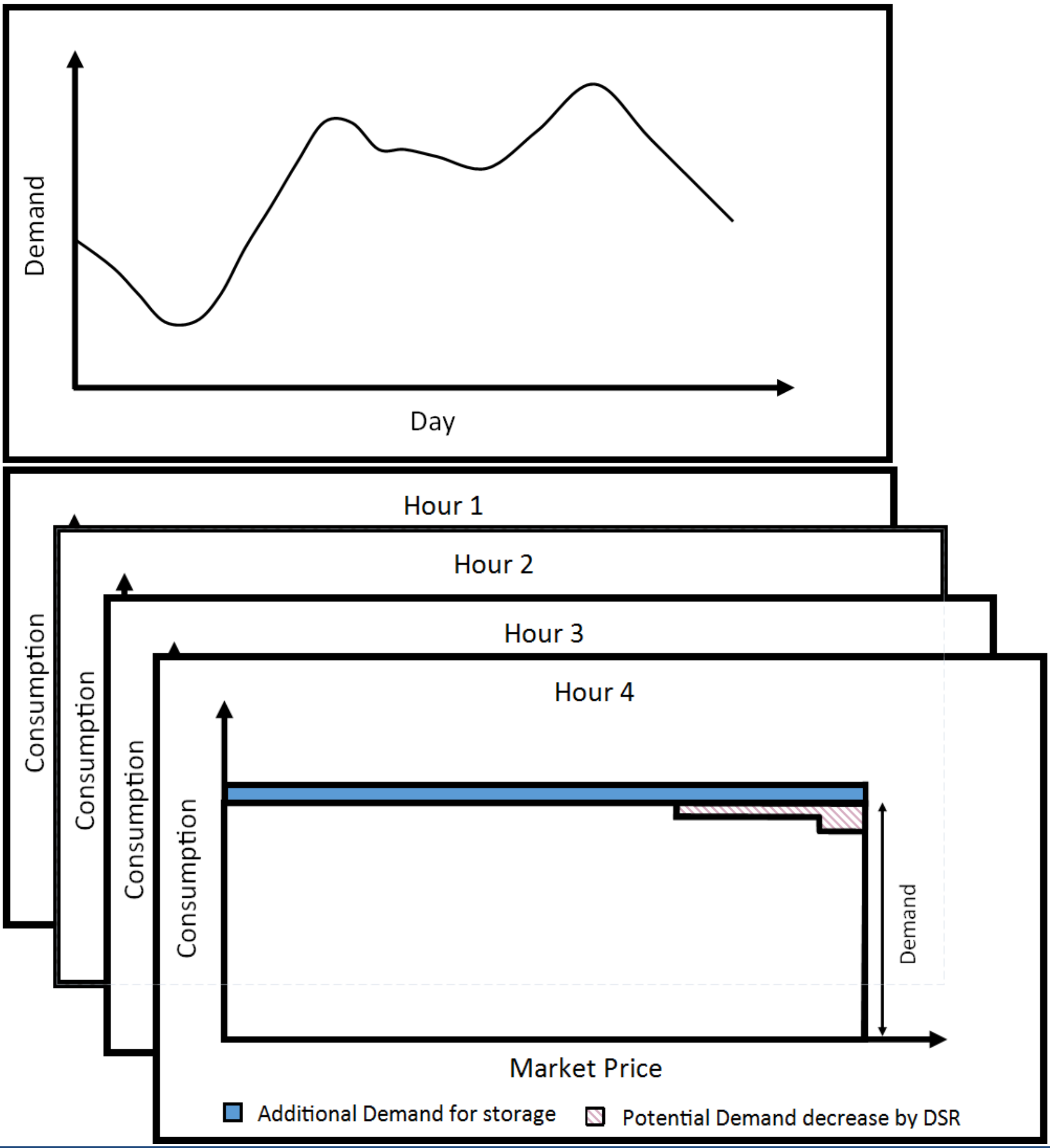
1. Demand

Demand data shall constitute of best estimates of demand available at the moment of assessment. These data sets shall especially reflect electric vehicle and heat pump penetration as well as electricity demand growth or decrease (e.g. under energy efficiency programs) assumptions. A number of demand profiles are created to represent demand variability in response to weather conditions.

Demand for system reserves shall be defined based on the practice of system operations of each specific system.

Furthermore, available contribution of market-based demand-side response as well as additional demand during charging of storage units shall be considered as individual elements responding to market signals. Demand-side response which provides system reserves shall be disregarded.

Example



2. Supply

Supply data shall include latest data on available supply resources considering planned and unplanned outages. Any supply resources shall be considered. Supply resources may be generation, storage and available exchanges with non-explicitly modelled neighbouring countries. Hydro generation shall be modelled considering energy availability.

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Definition Explanation – Planned Outage

These outages are all outages known at the moment of adequacy assessment. These include maintenances, existing outages due to forced outages and any supply unavailability due to other reasons.

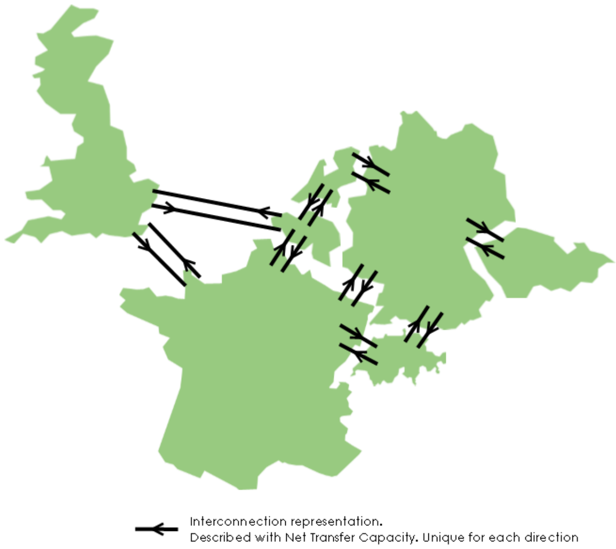
Definition Explanation – Unplanned Outage

These outages are not known in advance. Unplanned Outages may occur due to technical or human faults and are modelled as outages in addition to planned outages. A number of random drawings is taken considering forced outage rates of generation or transmission assets to consider such outages.

3. Grid

Zones are represented as copper plates (single nodes), which are coupled via modelled interconnectors. 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 considering the current market coupling of that region/country for each border and considering the current market rules (i.e. article 16 Electricity market regulation (EU) 2019/943). Grid representation shall be evolutive, considering market coupling of each specific region in all analyses (pan-European, regional and national), in line with Commission Regulation (EU) 2015/1222 of 24 July 2015 establishing a guideline on capacity allocation and congestion management.

Example – Net Transmission Capacity model



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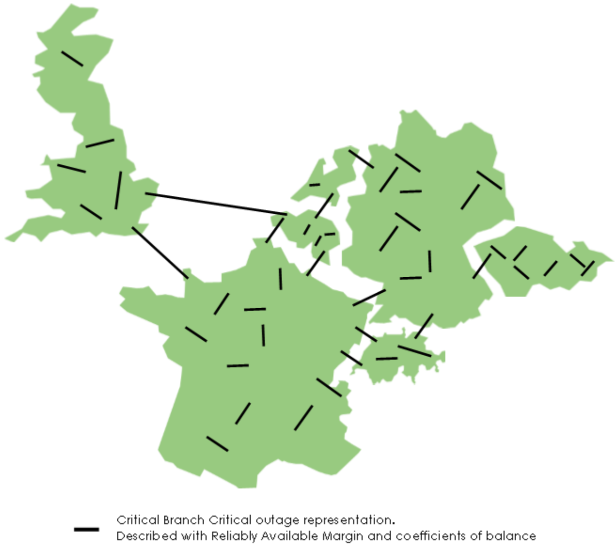
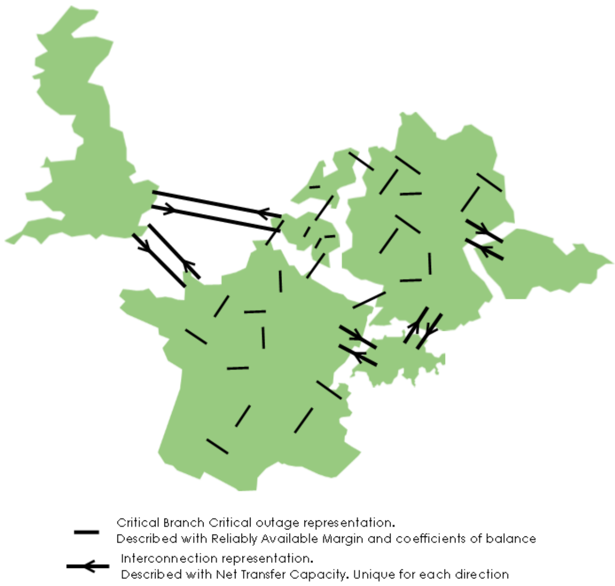
Example – Flow-Based model



Example – Combined model



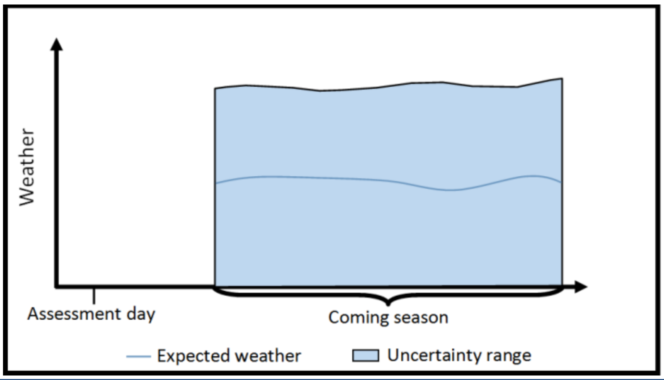
4. Climate Data

Various climate data are applied to consider variability of supply and demand. Wind, photovoltaic and concentrated solar power plant generation estimates as well as hydro inflow into hydro power plants are part of these data. Temperature is used to determine demand variability. Forecasts are always used if available at the time of assessment.

Seasonal adequacy assessments

These assessments are made rather far ahead of the considered season. The availability of forecasts for this time horizon is consequently limited and uncertainty is high. Therefore, a variability of weather patterns by means of numerous scenarios is considered to account for potential risks. Correlation of all variables is considered in time and space ensuring reliable assessment results.

Example

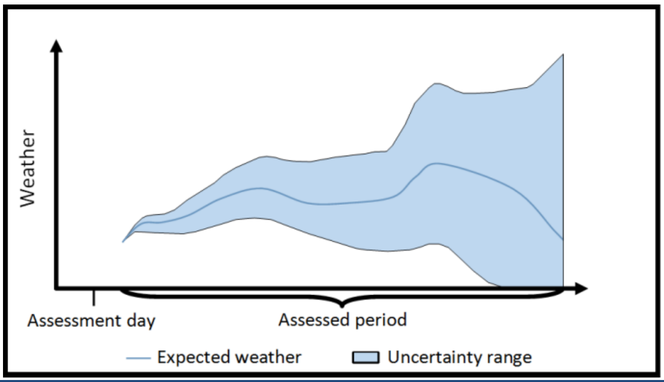


Short-term Adequacy Assessments

These assessments cover periods from at least day-ahead to month-ahead. Some forecasts are available for this period and considered in the study. Uncertainty of forecasts is also accounted for, considering that the uncertainty range of weather forecast decreases for study periods closer to the moment of assessment (e.g. day-ahead).

The set of scenarios is built considering forecast uncertainty in different time horizons. Furthermore, correlation between each variable is ensured in time and space, based on historical data reanalysis.

Example



VI Metrics

Metrics are measures to quantify and interpret adequacy assessment results. Careful selection of metric is important as well as an explanation of their meaning to the audience. Furthermore, different metric might be relevant for measuring adequacy assessment results for different analysis timeframes.

Seasonal adequacy assessment

A range of metrics may be used for seasonal adequacy assessments. Each metric might provide specific insight on adequacy assessment; therefore, a combination of metrics should be used. For example, there might be a risk of load shedding affecting a very small number of consumers but for an extended period. Because of this longer period, some might consider this risk as relevant. Further on, it might be the opposite as well–there might be a risk of very brief supply scarcity affecting many consumers, therefore the risk might be very relevant.

Potential and well-known probabilistic metrics are described below. However, in some specific cases other metrics might be used, which would help to identify and quantify risks. The need of such metrics might be considered in each study individually considering adequacy assessment results.

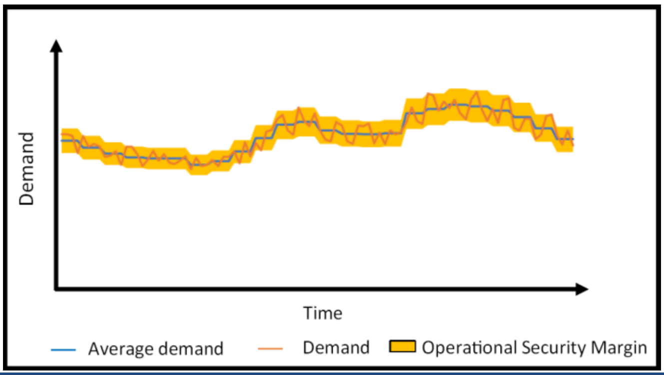
Loss of Load Expectation (LOLE) in a given geographical zone and for a given period is the expected number of hours during which a lack of market-based resources is expected to cover the demand needs with sufficient transmission grid operational security limits. This indicator is very useful to give an overview of adequacy over longer periods and is commonly used in adequacy assessments such as the mid-term adequacy forecast.

Explanation

Transmission grid operational security limits are margins necessary to ensure secure system operations. Those could be classified into two groups – power balance margins and network operational margins.

Network transmission grid operational security limits are ensured via the application of the N-1 operational security criterium. This security criterium ensures that any single contingency in a system can be managed. Furthermore, a security margin is applied when determining exchange capacities (reducing NTCs or RAMs).

Power balance margins are needed to cope with variations of demand, generation and exchanges between zones. These are ensured through balancing reserves. In adequacy assessments the capacity which is needed for balancing reserves is allocated to be always available for this purpose.



Expected Energy Not Served (EENS) in a given geographical zone and for a given period, is the energy (MWh) which is expected not to be supplied due to a lack of market-based resources retaining sufficient transmission grid operational security limits. This indicator describes the magnitude of adequacy issues expressed in energy for an analysed season.

Relative EENS is a more suitable metric to compare adequacy across geographical scope, as it represents the percentage of total demand (MWh) which is expected not to be supplied during the analysed period.

Loss of Load Probability (LOLP) in a given geographical zone and for a given period, is the probability to have a lack of market-based resources to cover the demand needs with sufficient transmission grid operational security limits. This indicator represents the likelihood of adequacy issues in an analysed period.

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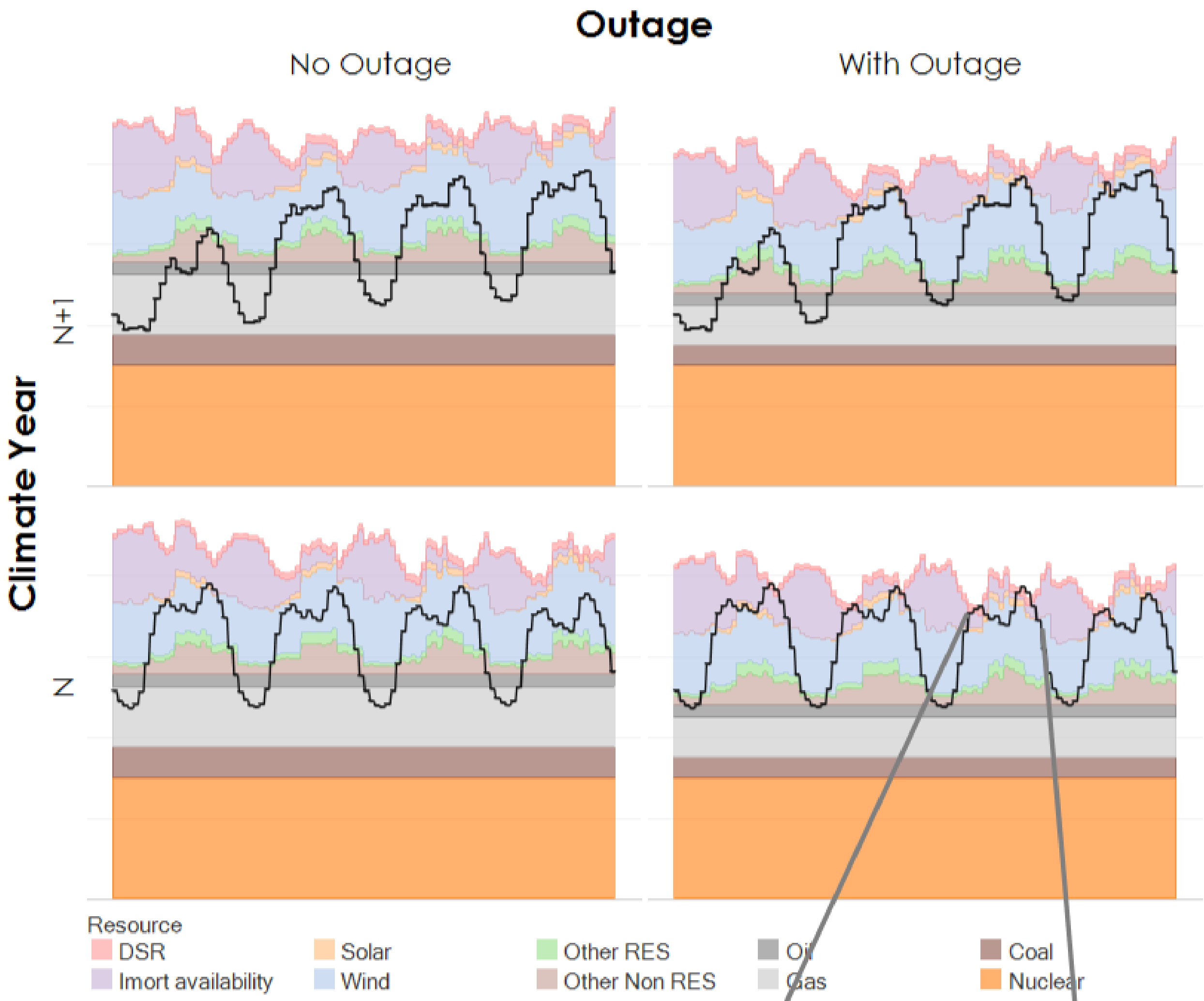
Example with 4 Monte Carlo samples



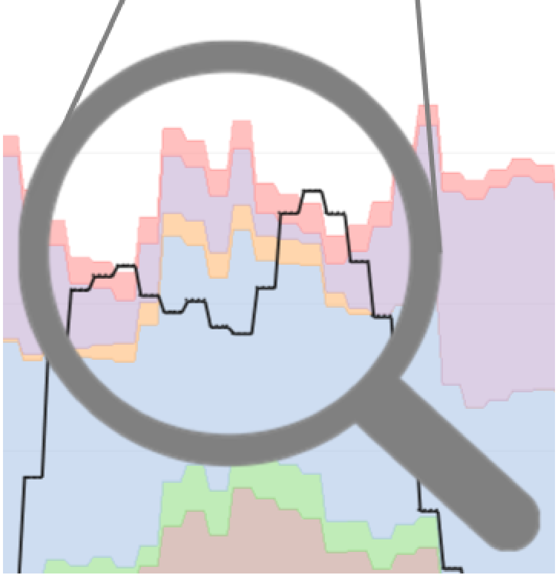
Indicators for this example period

LOLE—average number of hour with lack of market based resources to cover demand with sufficient security margins. LOLE = 3/4 = 0.75 h

EENS—energy which is expected not to be supplied with market based resources considering need of sufficient security margins. EENS is area between demand curve and resources divided by 4.

Relative EENS—EENS divided by annual typical consumption.

LOLP—probability of lack of market based resources to cover demand with sufficient security margins.
LOLP = 1/4 = 25%



Adequacy probability metric is the main indicator to assess short-term adequacy. Furthermore, other supporting metrics are used, such as EENS and LOLE. If a high risk is identified, further analysis is performed.

The value of the adequacy probability metric within a given geographical zone and for a given period, is the probability of market-based resources being sufficient to supply demand with sufficient transmission grid operational security limits. Sum of this indicator and LOLP yields 100%.

VII Result analysis

Result analysis (and presentation) is an integral part of the adequacy assessment. This step of adequacy assessment employs indicators as a means to present adequacy in the assessed geographical perimeter.

Seasonal adequacy assessment

The seasonal adequacy assessment shall consist of three main steps. First, a seasonal spatial screening shall be performed. The purpose of this is to give a general adequacy indication for the coming season in Europe. Second, a temporal screening shall be performed to analyse when adequacy risks are highest. Third, and if relevant, circumstances under which risks exist shall be investigated.

The spatial risk screening shall present a generic indicator for the coming season on the large geographical perimeter. This shall raise awareness of the adequacy situation in each assessed geographical zone as well as raise awareness of neighbouring zones. One of the potential indicators can be relative EENS, which is the ratio between the EENS during the assessed period and the zone demand during the same period.

Example

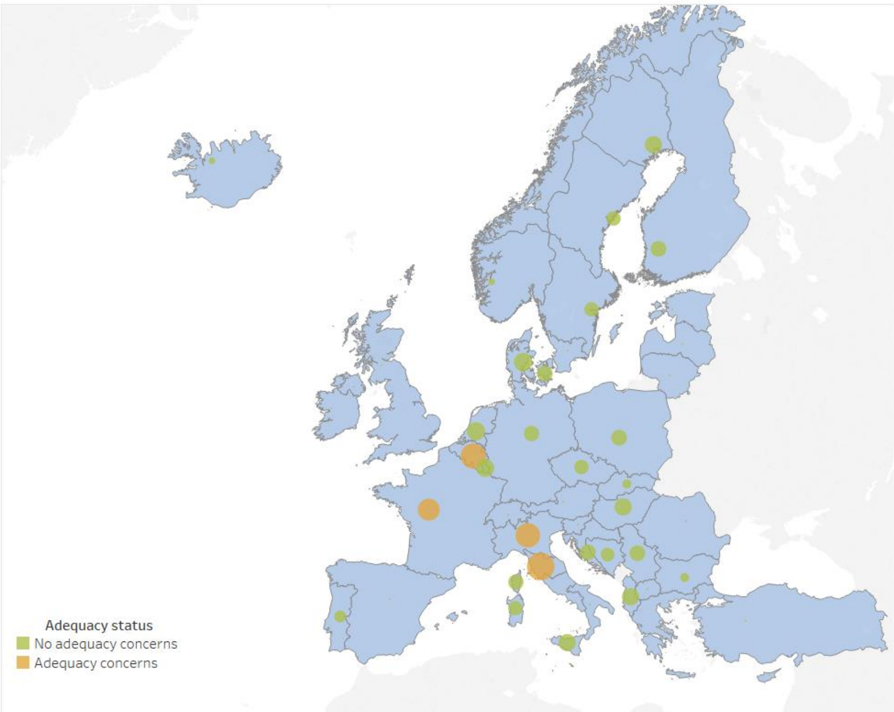


Figure 5: Principle of spatial screening (fictive example)

The temporal risk screening can be supported by a chart of LOLE or LOLP on European level on a weekly basis (Monday to Sunday). This would allow to detect which weeks are mostly at risk.

Example

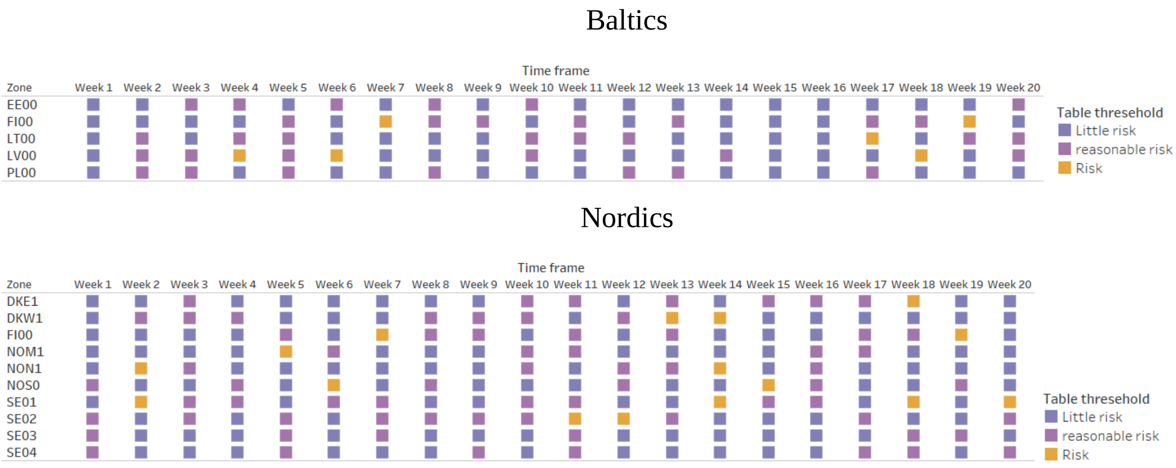


Figure 6: Principle of temporal screening (fictive example)

A dedicated risk analysis shall be performed on weeks with highest risks. This analysis shall focus on understanding the risk (magnitude, probability and any other related parameter) and identifying the circumstances when risks are relevant. Any tailor-made analysis might be executed for this purpose and will depend on the case-by-case situation. Some of the potential analyses which might be done are:

- 5th percentile of suppy margin (considering available imports) for each zone in given week. This would represent margin under severe conditions;
  - Supply margin – for a given time-step and zone, supply and import still available after demand is satisfied. In case of supply scarcity, reserve margin is negative and represents demand which would be needed to be shed.
- LOLP per zone on a daily basis. This could be used only if a relevant risk for a specific day is identified (e.g. risk due to coinciding maintenances on one specific day);
- Expected Energy Not Served (EENS) per zone on a daily basis during critical weeks;
- Distribution of the Energy Not Served within a week and a heat map of when it is most likely to occur.

Example

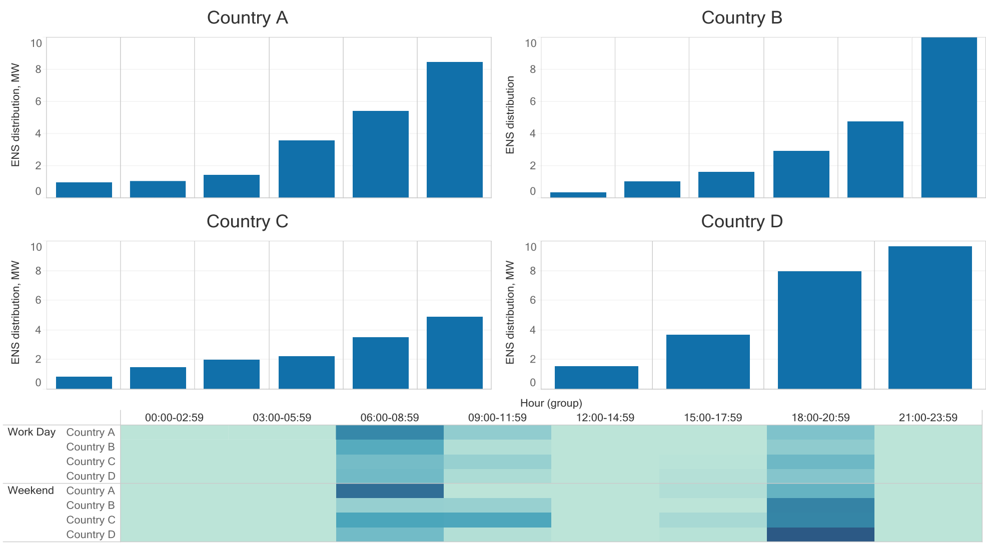


Figure 7: Focus on hourly risk within a given zone and week (fictive example)

For communication purposes it will be striven to communicate all results in a format which is easy to perceive for non-technical readers. Some indicators could be translated into ‘tangible’ numbers–e.g. to representative thousands of households’ equivalent under potential load shedding or converting it to relative numbers (relative EENS).

Short-term adequacy assessment

A short-term adequacy assessment is performed using a step-wise approach. First, an adequacy probability indicator is calculated for each zone on an hourly granularity. Consequently, a system-wide view is taken by investigating for each hour the lowest adequacy probability occurring in all zones under study. If at least for one hour an adequacy risk is identified, adequacy probability indicators are investigated for each study zone separately to understand the extent of the risk (whether nationally or regionally). Furthermore, adequacy under a predefined scenario (e.g. most likely operational conditions) is checked to quickly get a better insight on the risk. Lastly, resource availability and demand estimates are investigated to get a quality insight on adequacy risks and remaining resource margins for each system.

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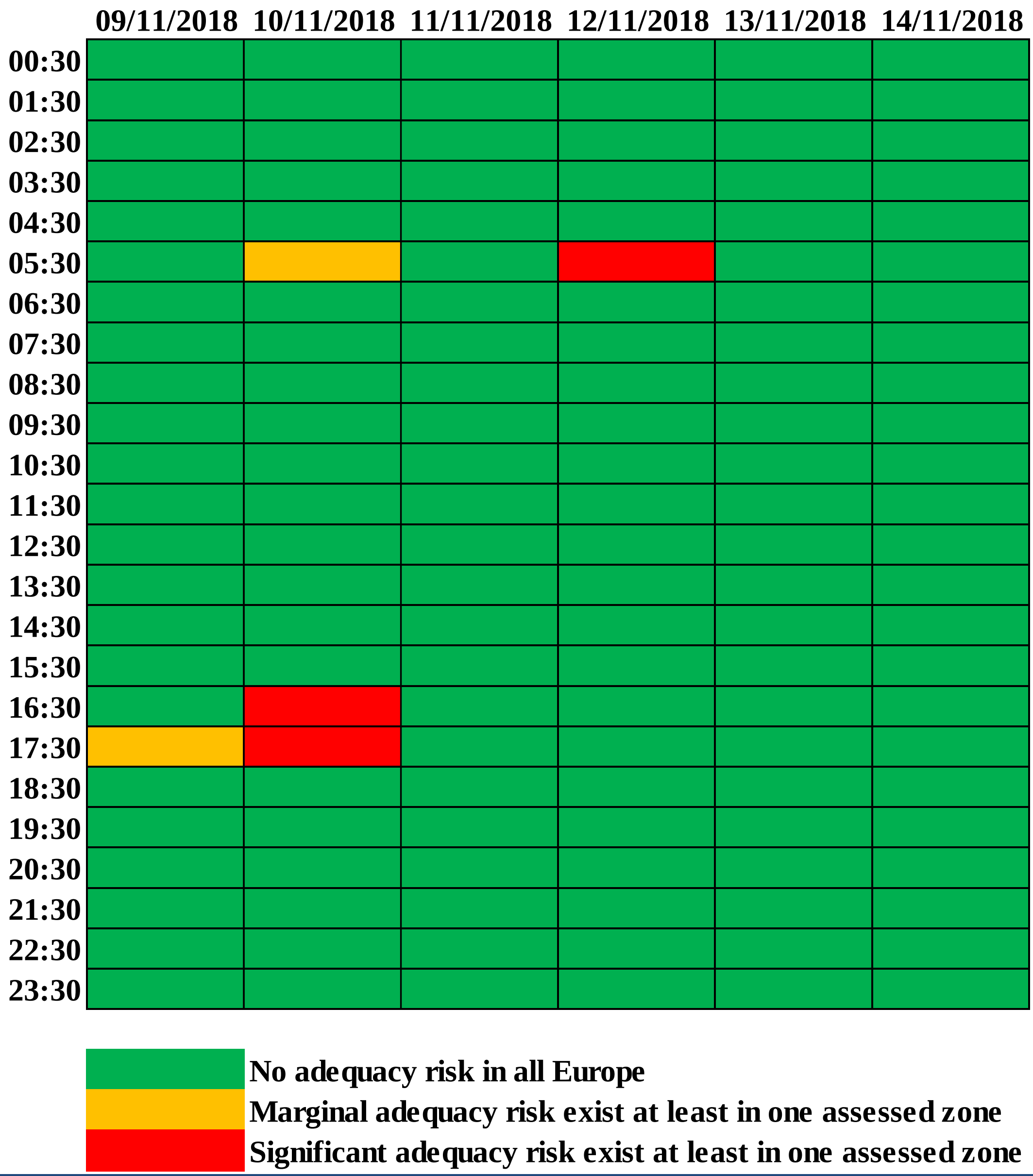
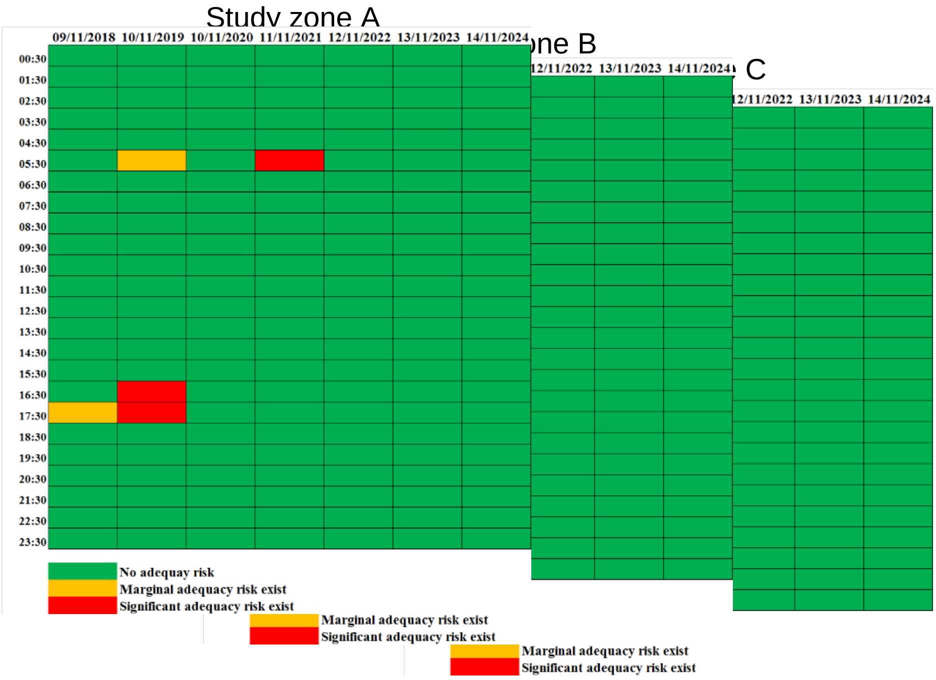
Examples

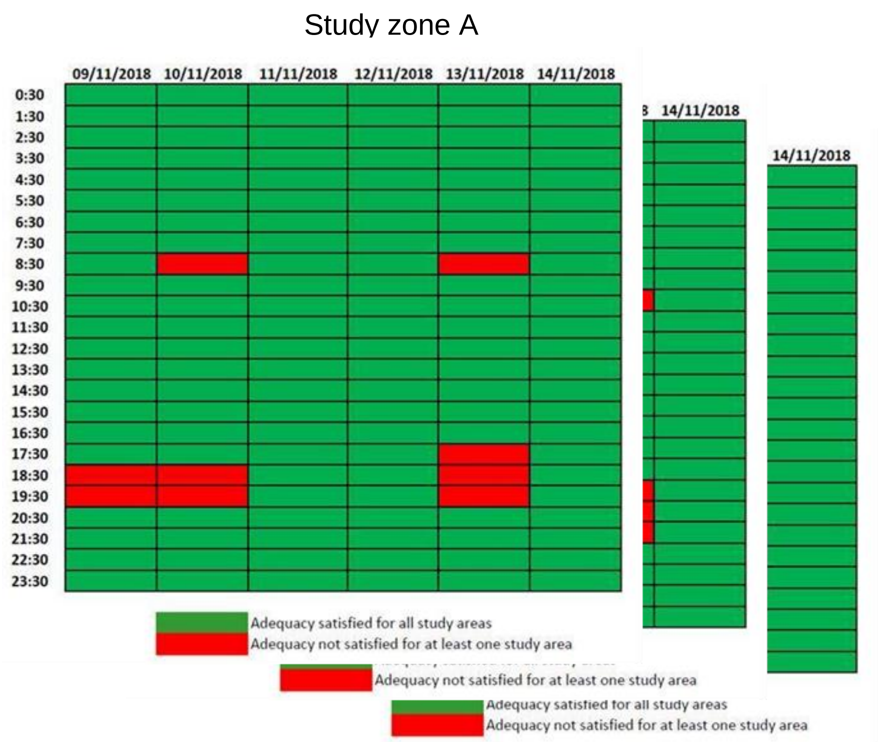
System-wide probabilistic results



Example–Study zone probabilistic results



Example–Adequacy under predefined scenario



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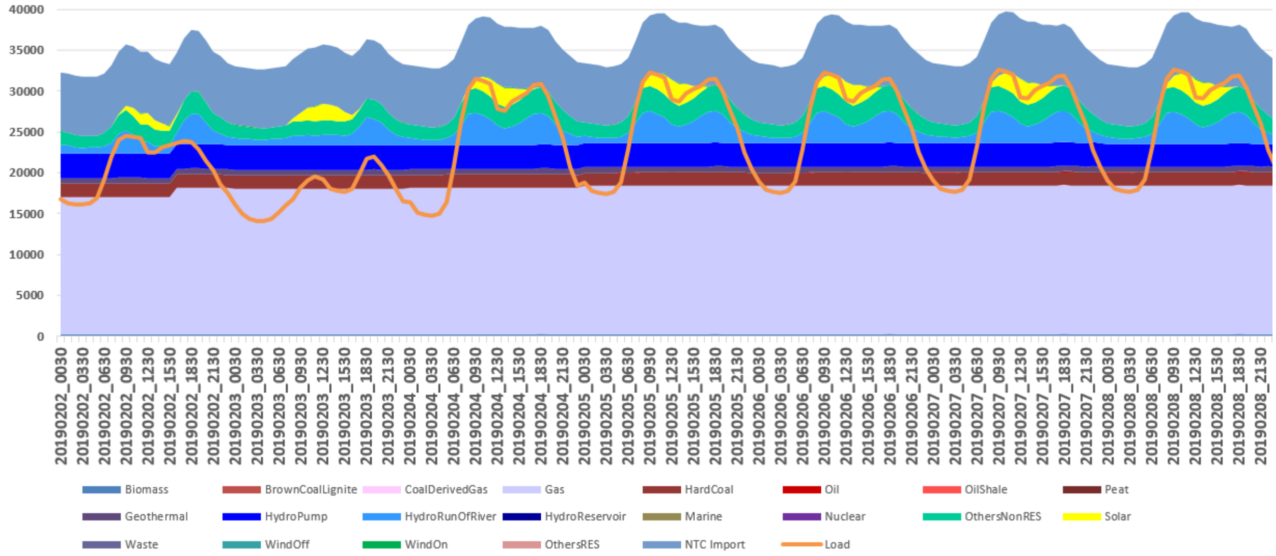
Example

Supporting graph to assess adequacy risks. Supply availability and demand graph, along many other, might be used for this purpose.



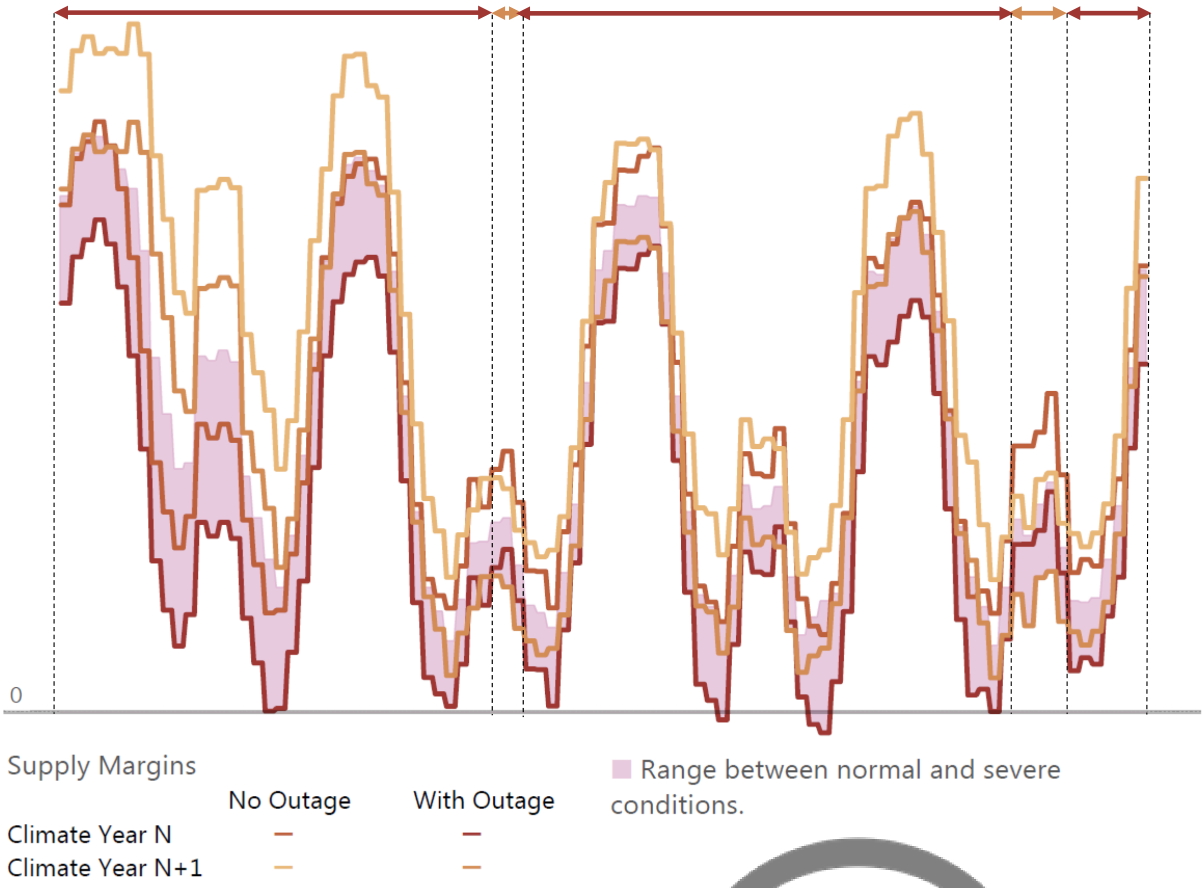
VIII Normal and severe conditions

Operational conditions are a combination of weather conditions and system element availabilities, which are either determined in advance (e.g. planned outages) or unknown in advance (e.g. unplanned outages), and include import potential. Operational conditions are a combination of all conditions leading to a specific margin in the system.

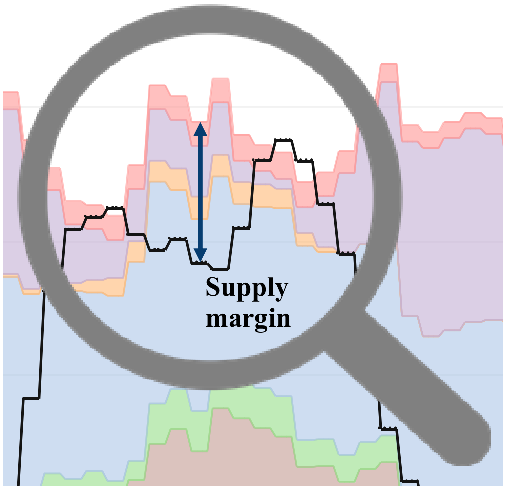
Normal operational conditions refer to typical operational conditions. This means that these are all possible combinations of weather conditions and system element availability scenarios leading to a median reserve margin (50^{th} percentile).

Severe operational conditions refer to extreme operational conditions. They are defined as all possible combinations of weather conditions and system element availability scenarios which lead to a reserve margin being close to the 5^{th} percentile.

Explanation–built on example with 4 Monte-Carlo samples in Section VI



Interpretation



Pink area represents supply margins (including available generation, DSR, imports and etc.) between normal and severe conditions. If supply margin of assessed scenario is below or close to bottom of this area, conditions might be considered as severe conditions.

Severe condition threshold is defined as 5th percentile of all possible supply margins. Normal condition threshold is defined as 50th percentile of all possible supply margins.

In given simplified 'Climate Year N with Outages' scenario conditions might be considered as severe condition definition. However, we may see that at some periods 'Climate Year N+1 with Outages' scenario represents severe condition situation.

Severe conditions might be supply margin level from high positive values to low negative–this is power system dependent characteristic. In exporting systems, it is likely, to be, but not necessary, high positive value, whereas in importing system it is likely to be, but not necessary, low negative value. In given example, it could be seen that under severe conditions resource margins get very tight.

With many analyzed scenarios (not presented in this example) combination of weather conditions and system element availabilities could be derived to describe severe and normal operational conditions.