European Network of Transmission System Operators for Electricity

ENTSO-E Target Methodology for Adequacy Assessment

Updated Version after Consultation

14 October 2014

1. Stakeholder Expectations

The main outcome of the inaugural consultation workshop on ENTSO-E methodology improvements for adequacy assessments held by TF ADAM on April 16th was the identification and prioritisation of the Stakeholders' expectations.

In response, and using their very same words, this document introduces to stakeholders some key specifications of a target methodology foreseen by TF ADAM. Its early validation or revision will ensure that the work will carry on accordingly.

Adequacy assessment is a fundamental method to measure whether the generation of electricity in a system meets the expected requirements and energy demand at a certain point of time. Historically the moment with the highest load was chosen for this kind of analysis, taking into account generation maintenance and outages and renewable energy reliability. Therefore, under consideration of uncertainties of data acquisition the probable most critical situation could be assessed.

Due to developments in the energy generation mix – more fluctuating renewables and less conventional fossil generation – the need of a more sophisticated assessment is necessary. With increase of renewables in the system the most critical situations may occur in future at times other than peak demand, for instance when the load is low and the in-feed of renewables is high. In addition to the assessment of whether the generation meets the demand, downward regulation and the need for more flexibility in the system share the centre of attention.

2. Existing Adequacy Reports Published by ENTSO-E

There are currently two kinds of adequacy forecast reports being published by ENTSO-E, each with its own time horizon: these are the short- and mid- and long- term reports.

However, in order to appreciate the content of this document, it is important to understand which report and which time horizon we are referring to when discussing the short, mid and long term reports. Therefore, when this document discusses the short term report it is referring to the Seasonal Outlooks reports, when this document discusses the mid-term report it is referring to The Scenario Outlook and Adequacy Forecast (SO&AF) and when it discusses the long term reports, it is referring to the Ten Year Network Development Plan and its Scenarios.

Short Term Outlook Reports

The seasonal Outlook reports are published twice a year just before the period covered in accordance with the Operational Planning & Scheduling (OP&S) network code and in accordance with Article 8 regulation (EC) 714/2009. They are the Winter and Summer Outlook reports which assess the adequacy of the power system for the coming season.

The short-term adequacy report focuses on exploring the main risks identified within a seasonal period. It looks at uncertainties such as climatic conditions and outages as well as other risks faced by the system including the evolution of load, load-management, generation capacities, and stability issues.

The ambition of these reports is to serve as a platform for information exchange amongst TSO's, as well as to promote transparency discussions and inform stakeholders on the potential risks in order for appropriate decisions to be made on topics such as: maintenance schedules, postponement in decommissioning and stakeholder awareness.

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Mid Term Reports

Annual adequacy forecast studies are published in the Scenario Outlook and Adequacy Forecast (SO&AF) report as part of the long-term network development package, the Ten-Year Network Development Plan and in accordance with regulation (EC) 714/2009.

The SO&AF report provides ENTSO-E with mid-term adequacy forecasts. The mid-term adequacy studies focus on exploring the main risks identified with a multi-year notice, which are above all the evolution of load, the commissioning and decommissioning of generation and load management capacities, the energy policies related to efficiency measures and the energy mix in particular.
The ambition of these yearly studies is to serve as an input for investment and energy policy decisions such as commission and decommissioning plans, political support schemes. The mid-term scenarios used are referred as Scenarios A (Conservative) and Scenario B (Best Estimate).

Long term scenarios which are used in the ENTSO-E network development plan (TYNDP) are built to satisfy overall adequacy requirements while exploring different pathways that the future power system could evolve into due to energy policies and global energy trends. Stakeholders are appropriately consulted as part of the extensive Ten Year Network Development Plan (TYNDP) consultation scheme on the construction of those long term scenarios.

3. Evolution of the Adequacy Reports

The aim of ENTSO-E is to maintain the above reports in order to assess the adequacy of the European power system.

Five key points have been identified by ENTSO-E in order to maintain the effectiveness of ENTSO-E's adequacy reporting. These include an extensive consultation process, improved transparency and input from stakeholders, harmonisation of local hypotheses and significant methodology evolution.

A second evolution for the reports is to maintain the distinction between each of the studies according to their time horizons and to focus each report on the most relevant risks faced by the system. This general idea applies in particular to scenario building for Seasonal Outlook reports (short-term horizon), yearly Adequacy Forecast reporting (mid-term horizon) and the Ten-Year Network Development Plan (long-term horizon), which all require different scenarios to explore the relevant risks.

As a consequence, it is of the utmost importance to clearly distinguish between the studies for long term network development plan and for mid-term adequacy forecast, which differ in goals, means, and horizons. An alternative way forward could be to publish the long term scenarios used in the Ten Year Network Development Plan (TYNDP) and the mid-term scenarios and related adequacy forecast assessment in two distinct documents, still ensuring they collectively form part of the TYNDP package as required by regulation (EC) 714/2009.

Considering Article 8 3(b) of regulation (EC) 714/2009 only requires publication of SO&AF every two years, an option to accelerate the evolution and improvement of the mid-term reports is to publish them every year and to include improvements of the proposed methodology in a stepwise manner in every report.

4. Timeline for the Consultation

5. Need for Flexibility

The large-scale exploitation of renewable energy sources of variable generation poses challenges for electricity system operation. As well as sufficient level of back-up capacity, additional resources of system flexibility are needed. At present, there is a risk that existing market designs might fail to deliver the necessary level of flexibility in the long term, affecting the availability of ancillary services, as well. Conventional power plants that can be considered as the main resources of flexibility in most countries have to face lower running hours resulting in reduced profitability while they are exposed to more changeable and variable load operating conditions.

The goal is to measure potential lack of flexible resources (generation and demand) in the expected power system operation. For this reason we are proposing to improve the adequacy methodology using probabilistic assessment methods to identify how often the system is not balanced and when availability of ancillary services might be affected. These changes are mostly caused by the actual hour-on-hour evolution of the climate situation and also by forecast errors in the planning processes.

As stated in the response paper[1] of ENTSO-E to the European Commission Consultation on Generation Adequacy, Capacity Mechanisms and the Internal Market in Electricity, ENTSO-E and its member Transmission System Operators can provide the necessary ‘technical analysis to determine threats to generation adequacy and its associated impacts on the security of supply’. Therefore the assessment of flexibility and the addressing of balancing issues are of key importance for methodology improvement in order to identify potential lack of flexible resources (generation and demand).

Assessment of the need for the flexibility

ENTSO-E will report on expected needs for flexibility in its adequacy assessments using a one-hour resolution as a first step. The existing Pan-European Climate Database (PECD) will be used for the assessment of weather-dependent effects related to load variation, generation patterns of wind and solar power plants and hydropower inflows.

[1] https://www.entsoe.eu/fileadmin/user_upload/_library/position_papers/20130207_ENTSOE_Response_to_EC_Consultation_Gen_Adeq__FINAL.pdf

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– **Variation of demand**

Demand variation and possible forecast errors constitute a large part of the need for flexibility. The annual, one-hour resolution load time series provided by TSOs for the pre-defined reference years are the basis of assessing the need for flexibility resulting from the variation of demand. In order to evaluate the possible critical situations for system operation, temperature sensitivity of demand should also be considered.

– **Variation of wind and solar power generation**

At present, the level of wind and solar energy exploitation is widely different across European countries. Therefore the availability of normalised time series derived from measurement data is limited. The PECD load factor datasets (synthetic time series derived from climate models) enable the coherent simulation of wind and solar production taking into account effects resulting from simultaneity. Despite the limitations in underlying assumptions (fixed amount and spatial distribution of generating capacity, limits in spatial and time resolution, fixed configuration of wind turbines and solar panels), the time series can serve as a basis for the assessment of the required additional flexibility.

– **Variation of hydro power inflows**

The volatility related to hydro power inflows can affect system adequacy, especially in systems which are hydro power dominated. This volatility should consequently be properly modelled as another important sources of uncertainty. Therefore, it will be considered to extend the ENTSO-E Pan European Climate Database (PECD) with hydro power inflow data.

Assessment of resources of flexibility

– **Thermal power plants**

Thermal power plants (fossil fuel and nuclear power plants) are a dominant source of flexibility in power systems. At present, only a classification by fuel type is considered in the outlook reports. The information on generating assets will be extended by including additional parameters enabling a more accurate assessment and power production simulations: type of plant, ramp rates (up/down), minimum and maximum stable generation, and minimum on and off times. Some thermal power plants are subject to must-run constraints resulting from technology, grid constraints, heat supply obligations etc.; this information should be collected and evaluated as well.

In addition to larger units, the potential flexibility of smaller-scale generation (modelled usually as an aggregated production) could be examined and assessed.

– **Storage**

At present, large-scale hydro storage is the most important resource of flexibility from storage. Similarly to the approach used for TYNDP 2014 market studies, data on minimum/maximum generation, pumping and inflow can be used as a basis of flexibility assessment. Other storage technologies like *e.g.* Compressed Air Energy Storage (CAES) will be considered, provided that reliable data can be collected.

– **Demand Side Management (DSM) / Demand Side Response (DSR)**

The load management range and the demand side contribution to the provision of the control reserves can be considered as a resource of flexibility. Some reference values are published in the present outlook reports, but more detailed data sets are needed for simulations. Methodologies currently used within TYNDP will be incorporated in the adequacy reports.

- ENTSO-E will report on expected needs for flexibility as part of its adequacy forecast.
- The adequacy analysis will be performed with an hourly resolution.

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– The Pan European Climate Database (PECD) will be used in modelling the volatility of load, wind, solar and hydro power generation.

6. Harmonization of methodology

The objective is to set a single core ENTSO-E adequacy methodology to perform Pan EU / Regional simulations. This methodology should be widely accepted by stakeholders.

The underlying assumptions should be harmonised to fully benefit from the assessment of the entire interconnected system as a whole. Thus, the datasets provided should have common underlying assumptions.

- TSO's should follow specific guidelines to calculate the figures requested (e.g. GDP used in the demand forecast)
- Some values could be built centrally to ensure consistency (e.g. RES capacity factors), and TSO's will have the opportunity to validate and modify these values.

- The SO&AF scenario building process and simulations should be transparent and publicly consulted on with stakeholders. This will require a strong interaction with stakeholders in several phases to get their buy-in. Moreover, the assumptions, datasets, process, and the timeline should be made publicly available. However, confidence in the results and confidentiality issues might require some data to be publicly released in an aggregated manner. The methodology should also take into consideration the recommendations from the e.g. Task Force (TF) Consistent Scenario Development and TF Scenario Building of ENTSO-E.

The core methodology should be the basis for short and mid-term reports (Outlook and SO&AF) even if slight variations might be required.

- The methodology should include a common set of indicators, same categories and definitions.
- The methodology could be built based on the existing Pan European databases for the TYNDP (PEMMDB)
- It is not ENTSO-E's mandate to further harmonise national approaches.

Differences in the current reports

Short term adequacy: Outlook reports

Generation capacity: The total installed capacity for each fuel type and RES type is collected on a weekly basis. Generation maintenance, outages and renewable energy reliability are considered.

Timeframe: The outlook reports cover the next half year. The data is on a weekly basis. The data is requested for synchronous time each Wednesday in order to allow meaningful analysis when determining cross border flows. It is recognized that this may not be the peak demand in every region but is chosen to allow a consistent analysis. Additionally minimum demand data, downward reserve requirement, level of inflexible plant, pumped storage demand are collected in order to allow an European overview of the need for countries to export across borders at times of high levels of inflexible generation such as wind or solar.

Scenarios: The report distinguishes between 2 scenarios (severe and normal conditions).

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Mid-term adequacy: SO&AF

Generation capacity: Power plant categories, taking into account some operational constraints such as maintenance.

Time frame: Data is collected for different time horizons and for different scenarios. The annual reference points are the 3rd Wednesday of January on the 19th hour (from 18:00 CET to 19:00 CET) and the 3rd Wednesday of July on the 11th hour (from 10:00 CEST to 11:00 CEST). Both have to fit into the general picture of the scenario.

Scenarios: 2 main scenarios (Conservative Scenario A, Best Estimate Scenario B). Scenario EU2020, based on NREAPs, has been considered in the last reports.

Possibilities of harmonization

Generation capacity: For harmonization between Outlook reports and SO&AF the collection of installed capacity of the Outlooks has to be adapted. The data collection will be expanded so that not only the installed capacity is collected but also the power plant category, number of units, must run etc. as in the SO&AF.

Timeframe: As the plan is to perform a market simulation on hourly resolution, the different points in time which are analyzed in the different reports are adapted to this resolution.

Scenarios: The focus in the mid-term and short-term reports is quite different. The analysis of a special scenario under severe conditions however can be omitted if it is decided to adopt a probabilistic approach.

Main indicators will be assessed in order to quantify the system adequacy and the need for flexibility, e.g. loss of load expectancy (LOLE), the loss of load probability (LOLP), effective load carrying capability (ELCC), etc. Another general indicators, such as CO_2 emissions and full load hours of generation will also be reported as an output of the simulations..

The datasets provided should have common underlying assumptions.

- TSO’s should follow specific guidelines to calculate the figures requested (e.g. GDP dependence of demand forecast, Temperature dependence of demand, level of penetration of EV, etc.)
- The data-structure must be extendable to future indicators depending on lessons learned from the process.
- The delivered data have to be harmonized with the neighbouring market areas in order to avoid data mismatch.
- Some values could be built centrally to ensure consistency (e.g. RES capacity factors) and transparent justification on the process followed will be provided.

- The core methodology will be the basis for short and mid-term reports.
- The methodology will include a common set of indicators, and the same categories and definitions.
- ENTSO-E will improve harmonisation through detailed transparency on input data.

7. Data transparency

Data transparency refers to the accessibility of the information of the processes involved in the developed calculation on the proposed methodology, as well as the outcome and the information itself without restrictions or exceptions. The transparency of the data is based on public access of TSOs, governments and TSO and companies related with ENTSO-E, and its quality. Transparency covers various subcategories of data, such as scenario definitions, sources, input and output data. Transparency of data in these subcategories will allow stakeholders to understand the evolution of the variables and parameters used in the methodology employed. However, confidence in the results and confidentiality issues might require some data to be publicly released in an aggregated manner.

Detailed specifications are necessary in order to have common understanding and use. The publication of the methodology is an important element in transparency and will be accessible through the continuous public consultations foreseen.

Transparency might improve understanding by stakeholders on the assumption and choices made by TSOs and ENTSO-E to deviate from the official policies and investment decisions in the ENTSO-E reports. This means credibility, reliability and demonstration of experience, contribution and a current positioning into policies and investment decisions of governments, TSO and related companies.

Examples of subcategories for input and output data are

The subcategories below presented are by no means final but provide examples of foreseen input and output data. These categories will be improved and expanded during the stepwise implementation of the methodology here proposed and for each of the proposed reports.

Input: referred to each proposed report

Generation Data: referred to each technology

- Capacity, technology;
- Maintenance programs;
- Fuel cost;
- CO2 rate;
- Non-Usable Capacity
- System Service Reserve.
- Must-runs constrains

Load: referred to each TSO, country, region and entire ENTSO-E area

- Load measurement
- DSM /DSR

Network: referred to each TSO

- Current nodes of the network
- NTC values for different weather conditions and period.

Output: referred to each proposed report

Generation Data: referred to each country, region and entire ENTSO-E area

- Estimated generation for technology.
- Estimated PV and Wind
- Detailed estimated Non-Usable Capacity

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- Estimated System Service Reserve
- Estimated full load hours of operation per technology
- Estimated level of RES curtailment

Load: referred to each country, region and pan-EU area

- Load forecast
- DSM forecast

Network: referred to each TSO

- Transfer capacity between country and region

Main indicators:

- Loss of load expectancy LOLE,
- Loss of load probability LOLP,
- Full load hours of generation
- RES curtailment
- CO_2 emissions

This information is classified according to cluster such as countries, region and pan-EU area for each scenario. The data providers are responsible for delivering up-to-date datasets according to the requirements of the methodology and guidelines defined. A possible option to ensure a better consistency of the underlying data collection assumptions could be to clearly specify centrally the exact data requirements for the analysis.

However, where TSO's are intermediary in the delivery of the data, the TSO's might not be responsible for the quality of (some of) that data. Multilateral cooperation with increased transparency from all parties is necessary.

ENTSO-E must fulfil obligations of Reg. 714/2009, and contribute to the overall European/national debates on adequacy concerns and in doing so it should respect national legislation and confidentiality agreements between TSOs and national stakeholders.

ENTSO-E is responsible for maintaining accessibility to information and for the methodology.

- The full data specifications and the ENTSO-E adequacy assessment methodology will be publicly available.
- The input data will be made publicly available, except data deemed confidential or sensitive.
- Confidentiality issues might require some data to be publicly released in an aggregated manner.

8. Cross border exchanges

An accurate adequacy assessment cannot avoid taking into account the role of interconnectors as a significant contribution to the ability of each area to balance its load and generation. In fact, the sharing of capacity between different interconnected areas allows each area to maintain the desired level of reserve with a lower amount of internal installed capacity (and consequently with lower costs) compared to the isolated operation. This role is actual and growing together with the development of interconnection lines, as foreseen in the ENTSO-E Ten Year Network Development Plan (TYNDP), and with the integration of the electricity markets on a Pan-EU scale toward the Internal Electricity Market (IEM) target model. Furthermore, during the ENTSO-E workshop and web-survey on adequacy methodology in April, Stakeholders selected this as one of the top five priorities for the ENTSO-E adequacy methodology evolution.

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In the current ENTSO-E adequacy methodology the contribution of the interconnection to the system reliability is taken into account differently according to time horizon: while in the seasonal outlook reports a simplified multi-area assessment has already been introduced in the recent years, in the Scenario Outlook & Adequacy Forecast (SO&AF) the possibility of sharing the capacities among different areas is not yet modelled. Hence, a harmonized approach for properly modelling the contribution of cross-border interconnections on adequacy will be adopted in the future ENTSO-E methodology in order to capture all benefits related to the implementation of the internal energy market.

Methodology evolution

In the target ENTSO-E adequacy methodology a multi-area adequacy assessment will complement the local national perspective, both in the seasonal outlook reports and in the SO&AF. The whole area in the geographical scope of the assessment will be consequently modelled as a number of interconnected areas connected by interfaces with limited transmission capacities[2].

Although a model which simply simulates the exchange of capacity margins might be enough for an adequacy assessment, the future ENTSO-E adequacy studies will be integrated with appropriate market simulations. These simulations will provide an estimation of the expected cross-border flows and, in addition, such modelling will allow ENTSO-E to produce an extensive range of indicators. The main indicators for adequacy assessment are: Loss of load expectancy LOLE, Loss of load probability LOLP, Full load hours of generation and RES curtailment. Estimated marginal technology and CO_2 emissions have also been listed by the Stakeholders as the most interesting indicators.

Hence, the level of reliability of the Pan-EU electricity system will be assessed throughout a chronological hourly simulation of the whole interconnected system in which, for every time point (hour), an optimization procedure will try to cover the estimated load demand of each area using the generation capacity available both inside the area and in the other areas, according to their merit order and properly taking into account the constraints on the interconnections.

Cross-border capacities modelling

In order to properly take into account the impact of cross-border interconnections in the adequacy assessments, the available cross-border capacity for each connection in each direction and at each time point should be defined.

To do so, we need a harmonized methodology to model the contribution of cross-border exchanges to adequacy. Such model should consider the limited capacities between areas of the interconnected grid and properly evaluate the potential support provided by the interconnections to each area.

Two options have been identified to evaluate the constraints on the interconnections:

- An Available Transfer Capacity approach (ATC), in which the physical capacities of the grid are implicitly taken into account and given to the markets.
- A flow-based approach, in which the physical capacities of the grid are explicitly modelled through the impedance and a maximum transit value for each branch of a simplified grid model.

To describe the constraints on the interconnection, the ATC (Available Transfer Capacity) approach, which has been used for four years in the TYNDP market studies and also in the most recent seasonal outlook reports, will be adopted in the target ENTSO-E adequacy methodology.

[2] With the underlying assumption that there are no transmission limits within an area.

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This approach has been selected because it is easier to implement in the usual simplified way applied in operations and because it is widespread on the whole geographical scope of the Pan-EU adequacy assessments. In the future, when the Flow Based (FB) approach will be much more widespread and its application will be consolidated on a broader geographical area, a possible evolution of the methodology toward this approach could be foreseen.

The ATC values are usually available for the short term time horizon (seasonal outlook reports) and for the long-term time horizon of the TYNDP scenarios. They will have to be estimated for the mid-term time horizon of the adequacy forecast (SO&AF). These values should also take into account a properly estimated impact of grid outages (planned or forced) and generation dispatch. A harmonized methodology to assess these parameters should be defined.

For the scope of the adequacy assessments, the available capacity in each time point of the simulations on a border can be seen as the difference between two main factors:

a) ATC value in a fully operative grid condition ($ATC^{f.o.g.}$)
b) ATC reduction due to planned or forced outages ($ATC^{reductions}$)

$$ATC_{A\rightarrow B}(h) = ATC_{A\rightarrow B}{}^{f.o.g.}(h) - ATC_{A\rightarrow B}{}^{reductions}(h)$$

The procedure selected in order to estimate these values for the future adequacy assessments is strictly related to the time horizon.

Short term time horizon: seasonal outlook reports

- **A best estimation of the ATC values in a fully operative grid** condition for the time period covered by the simulation will be available: TSO's calculation for the capacity allocation processes are typically performed before the adequacy assessment's deadline. At each time point, these parameters will be set or, where it is appropriate, they will be modelled as a function of some other input values (e.g. C-function in the CWE which relates the ATC value to the German wind infeed).

– **Grid and generation outage plans** for the time period covered by the simulation will be available, as they will have been already approved by the involved parties before the start of the adequacy assessment. Therefore a part of the ATC reduction term will be set and already known. Hence, at each time point, the ATC reductions related to planned outages will be simply subtracted to the fully operative grid condition ATC values.

– In addition, **random forced outages** will be simulated to properly take into account the impact of them on the ability of the areas to share their reserves, and the consequent ATC reductions will be applied in the model.

Mid-term time horizon: (SO&AF)

– **A best estimation of the ATC values in a fully operative grid condition** for the time period covered by the simulation will be derived, according to the TYNDP projections, by the concerned TSOs. In each time point, these parameters will be set or, where it is appropriate, they will be modelled as a function of some other input values (e.g. C-function in the CWE which relates the ATC value to the German wind infeed).

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– **Grid and generation outage plans** for the time period covered by the simulation will not be available. Hence, a proper methodology able to estimate both planned and forced outages impact on the ATC values will be adopted.

- OPT1: While forced outages impacts will be modelled in the same way as the short-term studies, planned outages will be taken into account through an automatic algorithm which will allocate the maintenance periods (estimated according to historical series) in order to minimize the impacts on the adequacy of the system.
- OPT2: The total amount of ATC reductions can be probabilistically modelled according to availability historical data of the interconnections.

Although the exchange of capacity margins might be enough for a simple adequacy assessment, there is much more interest in a proper evaluation of the expected cross-border flows which requires market modelling including optimal dispatch. In addition, such modelling will allow ENTSO-E to produce an extensive range of indicators e.g. loss of load expectancy LOLE, the loss of load probability LOLP, full load hours of generation, RES curtailment, effective load carrying capability ELCC, etc. In addition other types of general indicators, such as CO2 emissions will also be reported as an output of the simulations since have been listed as indicators of importance by Stakeholders.

To correctly model the power flows, the areas in the analysis should be in line with the Bidding Zones configuration. However, it is important to note that it is not the scope of adequacy methodology and studies to review bidding zone perimeters themselves are ongoing within ENTSO-E. It is assumed that the most significant network constraints are already and will be reflected in the Bidding Zone definition. While bidding zones seem to be the most suitable perimeter for grid modelling, reporting will remain at a national level as well.

Probabilistic simulation of interconnector availability

In order to properly take into account the probabilistic behaviour of the forced outages, the future adequacy methodology will be based on a Probabilistic simulation approach.

In a Probabilistic approach, a series of time points of the system, obtained by random drawings of each input variable (e.g. RES infeed, load demand, status of generating units, status of the interconnectors), are simulated. Consequently, the desired performance indicators can be assessed for each simulated time point. Two kinds of Probabilistic simulation techniques exist: non-sequential and sequential.

A non-sequential simulation process considers each time point as independent. Consequently, a non-sequential approach does not accurately model phenomena that involve correlations among different time points. In this approach the duration of a forced outage cannot be properly modelled, while its probability of occurrence can be modelled through forced outage rates (FOR) of the different elements which affect the cross-border exchanges.

A sequential simulation process steps through time chronologically, recognizing that the status of each element is not independent of its status in the other time points. Therefore, forced outages can be modelled by taking the element out of service for contiguous time points, with the duration of the outage period determined from a properly defined restoration time.

Therefore, in order to properly take into account the contribution of the interconnectors to the system adequacy, each interconnection between adjacent areas will be described by the list of the element which can affect the ATC values and the related ATC reductions in case of their unavailability. Additionally, statistical values about their availability in the past will be collected to model forced outage occurrences.

Hence, forced outage occurrence can be modelled as follows:

- In a non-sequential Probabilistic approach, in each simulated time point, a random number between 0 and 1 can be extracted for each element of the list, if this number is below the FOR of the correspondent element, this element is considered out of services and the related ATC reduction is applied. This modelling approach is simple to be applied and the data to be collected are limited (list of the elements which affect the ATC values and the related ATC reductions, FOR values for each element or cluster of elements).

- In a sequential Probabilistic simulation, a more complete forced outages model can be applied. Assuming that the outage rate is constant over the simulation time period, an exponential distribution can be adopted to randomly determine the fault probability, while different kind of distribution can be selected (e.g. exponential, lognormal) to model the repair times for each element. Obviously, this modelling approach is more complex to apply and implies a more extensive data collection (list of the elements which affect the ATC values and the related ATC reductions, forced outages historical data or key parameters for each element or cluster of elements).

– The future ENTSO-E methodology for adequacy assessment will properly take into account the contribution of the cross border exchanges.
– A market model will be used in the future ENTSO-E methodology for adequacy assessment in order to evaluate the expected role of interconnectors.
– The Available Transfer Capacity (ATC) approach will first be used to model the cross-border exchanges in the future ENTSO-E methodology for adequacy assessment.
– The areas in the analysis should be in line with the Bidding Zones configuration.

9. Deterministic VS Probabilistic

The objective is to implement a probabilistic methodology to better model the volatility and uncertainties of the system, and meet stakeholders' expectations.

The ENTSO-E methodology will be a probabilistic approach and enable the evaluation of stochastic effects (e.g. severe weather conditions, their duration etc.). However, the transition of the methodology should be a gradual step by step approach. Risks due to severe climatic situations will be accounted by consideration of statistically relevant and climatically correlated ensembles of time series of RES, inflow and load including low and high RES in-feeds, dry and wet years of inflow and high and low demand.

The existing deterministic assessment has some merit in the simplicity and stability of communication of the results. Thus, it could be useful to derive it from the datasets collected for the new probabilistic methodology.

- The ENTSO-E target modelling for adequacy assessment will also take probabilistic information into account.
- The transition of the methodology will be a gradual step by step approach, to be further specified for each report.

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