European Network of
Transmission System Operators
for Electricity

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Proposal for a Methodology for calculating the Value of Lost Load, the Cost of New Entry for generation, or demand response, and the Reliability Standard in accordance with Article 23 of the Regulation (EU) 2019/943 of the European Parliament and of the Council of 5 June 2019 on the internal market for electricity (recast)

Date: 5 December 2019

DISCLAIMER
This document is released on behalf of the ENTSO-E only for the purposes of the public consultation on the ENTSO-E proposal for European Resource Adequacy Assessment Methodology (the Methodology) in accordance with Articles 23 of the Regulation (EU) 2019/943 of the European Parliament and of the Council of 5 June 2019 on the internal market for electricity (recast). This version of the Methodology Proposal does not in any case represent a firm, binding or definitive ENTSO-E position on the content.

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Whereas

This document is a proposal developed by the European Network of Transmission System Operators for Electricity (hereinafter referred to as "ENTSO-E") regarding the calculation of the Value of Lost Load, the Cost of New Entry for generation, or demand response, and the Reliability Standard (hereafter referred to also as "Methodology") in accordance with Article 23 of Regulation (EU) 2019/943 of the European Parliament and Council of 5 June 2019 on the internal market for electricity (recast), hereinafter referred to as Regulation (EU) 2019/943.

(1) The Methodology takes into account the general principles and goals set in the Regulation (EU) 2019/943 as well as the European Union (EU) legal framework [Regulation (EU) 2019/941 of the European Parliament and of the Council of 5 June 2019 on risk-preparedness in the electricity sector, Commission Regulation (EU) 2015/1222 of 24 July 2015 establishing a guideline on capacity allocation and congestion management ("CACM Regulation"), Commission Regulation (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation, ("SO GL")].

(2) The goal of the Regulation (EU) 2019/943 is to ensure the most effective and efficient provision of resource adequacy within the EU. In order to achieve this goal, this Methodology establishes a common approach in all adequacy assessments whether carried out at national, regional, or Union level.

(3) The obligation of Member States to estimate the Value of Lost Load is set out in Article 11(1) of the Regulation (EU) 2019/943 "…[r]*egulatory authorities or, where a Member State has designated another competent authority for that purpose, such designated competent authorities shall determine a single estimate of the value of lost load for their territory. That estimate shall be made publicly available.*"

(4) The geographic scope of the Value of Lost Load estimation is set out in Article 11(1) of the Regulation (EU) 2019/943: "*Regulatory authorities or other designated competent authorities may determine different estimates per bidding zone if they have more than one bidding zone in their territory. Where a bidding zone consists of territories of more than one Member State, the concerned regulatory authorities or other designated competent authorities shall determine a single estimate of the value of lost load for that bidding zone*".

(5) The frequency of the Value of Lost Load estimation is set out in Article 11(2) of the Regulation (EU) 2019/943: "*Regulatory authorities and designated competent authorities shall update their estimate of the value of lost load at least every five years, or earlier where they observe a significant change*".

(6) The requirement for ENTSO-E to conduct European resource adequacy assessment is set out in Article 23(1) and (2) of the Regulation (EU) 2019/943: "*1. The European resource adequacy assessment shall identify resource adequacy concerns by assessing the overall adequacy of the electricity system to supply current and projected demands for electricity at Union level, at the level of the Member States, and at the level of individual bidding zones, where relevant. The European resource adequacy assessment shall cover each year within a period of 10 years from the date of that assessment. 2. The European resource adequacy assessment shall be conducted by the ENTSO for Electricity*".

(7) The assessment of the Expected Energy Not Served and Loss of Load Expectation during the resource adequacy assessment is set out in Article 23(5)(j) of the Regulation (EU) 2019/943: "*The European resource adequacy assessment shall be based on a transparent methodology which shall ensure that the assessment:* […] *(j) includes at least the following indicators referred to in Article 25: – 'expected energy not served', and – 'loss of load expectation'*".

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(8) The requirement for ENTSO-E to draft a Methodology for estimating the Value of Lost, the Cost of New Entry and to set the Reliability Standards is provided in Article 23(6) of the Regulation (EU) 2019/943: "*By 5 January 2020, the ENTSO for Electricity shall submit to ACER a draft methodology for calculating: (a) the value of lost load; (b) the cost of new entry for generation, or demand response; and (c) the reliability standard referred to in Article 25. The methodology shall be based on transparent, objective and verifiable criteria*".

(9) The process of consultations and approval of the Methodology for calculating the Value of Lost Load, the Cost of New Entry for generation, or demand response, and the Reliability Standards is set out in Article 23(7) of the Regulation (EU) 2019/943: "*The proposals under paragraphs 3 and 6 for the draft methodology, the scenarios, sensitivities and assumptions on which they are based, and the results of the European resource adequacy assessment under paragraph 4 shall be subject to the prior consultation of Member States, the Electricity Coordination Group and relevant stakeholders and approval by ACER under the procedure set out in Article 27*".

(10) The geographic scope for the Reliability Standard is set out in Article 25(1) of the Regulation (EU) 2019/943: "*When applying capacity mechanisms Member States shall have a reliability standard in place. A reliability standard shall indicate the necessary level of security of supply of the Member State in a transparent manner. In the case of cross-border bidding zones, such reliability standards shall be established jointly by the relevant authorities*".

(11) The definition of the Reliability Standard is delegated to the Member State according to Article 25(2) of the Regulation (EU) 2019/943: "*The reliability standard shall be set by the Member State or by a competent authority designated by the Member State, following a proposal by the regulatory authority. The reliability standard shall be based on the methodology set out in Article 23(6)*".

(12) The requirement for the indicators to be used in the Reliability Standard definition is set out in Article 25(3) of the Regulation (EU) 2019/943: "*The reliability standard shall be calculated using at least the value of lost load and the cost of new entry over a given timeframe and shall be expressed as 'expected energy not served' and 'loss of load expectation'*".

(13) In conclusion, the Methodology contributes to the general objectives of the Regulation (EU) 2019/943 to the benefit of all market participants and electricity end consumers.

TITLE 1
General provisions

Article 1
Subject matter and scope

1. This Methodology provides the criteria for calculating the Value of Lost Load, the Cost of New Entry for generation, or demand response, and the Reliability Standard referred to in Article 25 of the Regulation (EU) 2019/943 in accordance with Article 23(6) of the Regulation (EU) 2019/943.

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Article 2
Definitions and interpretation

1. For the purpose of the Methodology, the terms used in this document shall have the meaning of the definitions included in Article 2 of the Regulation (EU) 2019/941[1], Regulation (EU) 2019/943 and Directive (EU) 2019/944[2].

2. In addition, in this Methodology, unless the context requires otherwise, the following terms shall have the meaning below:

- Annual Fixed Costs: costs incurred in the context of operation of a capacity resource each year once the capacity resource starts operating, independently from the generated or curtailed energy volume.
- Capacity Mechanism (CM): an administrative measure to ensure the achievement of the desired level of security of supply by remunerating capacity resources for their availability not including measures relating to ancillary services as referred in Article 2 of the Regulation (EU) 2019/943.
- Capital Costs: costs incurred during the Construction Period of the capacity resource.
- Construction Period: period between the investment decision and the time when the capacity resource becomes operating.
- Cost of Capital: the minimum return that is required by a company to make a new investment.
- Cost of Debt: the return that a company provides to its debtholders and creditors.
- Cost of Equity: the rate of return a shareholder requires for investing equity into a business.
- Cost of New Entry or gross Cost of New Entry (CONE): the total annual net revenue per unit of de-rated capacity (net of variable operating costs) that a new generation resource or demand-side response would need to receive over its economic life in order to recover its capital investment and fixed costs.
- Country Risk Premium: additional returns expected by the investor in order to assume the risk of investing in a particular country compared to a reference country considered as stable and less risky.
- Demand-Side Response (DSR): the change of electricity load by final customers from their normal or current consumption patterns in response to market signals, including time-variable electricity prices or incentive payments, or in response to acceptance of the final customer's bid, alone or through aggregation, to sell demand reduction or increase at a price in organised markets as referred in Article 2 of the Directive (EU) 2019/944. DSR can consist either in a reduction or in a time shift of demand.
- De-rated Capacity: capacity of an electricity source, which is likely to be technically available to operate at times of System Stress events.
- Economic Lifetime: the period of operation over which the initial capital investment is expected to be recovered by rational investors.

[1] Regulation (EU) 2019/941 of the European Parliament and of the Council of 5 June 2019 on risk-preparedness in the electricity sector and repealing Directive 2005/89/EC, OJ L 158 [hereinafter "Regulation (EU) 2019/941"].
[2] 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, OJ L 158 [hereinafter "Directive (EU) 2019/944"].

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- Electricity Markets: markets for electricity, including over-the-counter markets and electricity exchanges, markets for the trading of energy, capacity, balancing and ancillary services in all timeframes, including forward, day-ahead and intraday markets.
- Energy Not Served (ENS): the annual demand (in MWh) that is not served from market-based resources, e.g. due to the demand exceeding the available generating capacity and the electricity that can be imported in a market node.
- Equivalent Annualised Cost: constant annual payment over Economic Lifetime for which the Net Present Value over the period of the Construction Period and the Economic Lifetime is equivalent to that of a cash flow represented by the Capital Costs and Annual Fixed Costs over the same period.
- Equity Beta: measure of the volatility of a given stock's price movement relative to the overall market's movement.
- Equity Risk Premium: refers to the excess return that investing in the stock market provides over a Risk-free Rate, over the same time period.
- Expected Energy Not Served (EENS): the expected value of the annual Energy Not Served.
- Gearing: ratio of debt compared to total assets of one company.
- Loss of Load Expectation (LOLE - in hours): the expected number of hours per year during which the demand cannot be covered by market-based resources, i.e. the demand exceeds the available generating capacity and the electricity that can be imported in the market node and a positive ENS is observed.
- Peer Companies: group of companies that share similar characteristics (business, generation portfolio, size, region, etc.).
- Regulatory Authority (RA): regulatory authorities or, where a Member State has designated other competent authorities for that purpose, such designated competent authorities, in charge of determining a single estimate of the value of lost load for their territory.
- Reliability Standard: measure of the necessary level of security of supply.
- Risk-free Rate: represents the interest an investor would expect from a risk-free investment over a specified period of time.
- Value of Lost Load (VoLL): an estimation in EUR/MWh of the maximum electricity price that customers are willing to pay to avoid an outage, as referred in Article 2 of the Regulation (EU) 2019/943.
- System Stress: period when adequacy is expected to be at risk.

3. In this Methodology, unless the context requires otherwise:

- the singular indicates the plural and vice versa;
- 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.

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TITLE 2
Calculation of the Value of Lost Load

Article 3
Consumer segmentation

1. The RA shall specify which categories of consumers should be considered when evaluating the VoLL caused by an adequacy outage among domestic consumers, the tertiary sector, transport and industries. In particular, VoLL only concerns the inelastic demand, so price-elastic consumers which are not considered to suffer ENS as they are considered as DSR in the resource adequacy assessments should be excluded from the VoLL estimates. The RA shall evaluate separately the VoLL for each concerned category following the principles described in Articles 5, 6 and 7. The final single VoLL calculation is detailed in Article 8.

Article 4
VoLL parameters for adequacy issues

1. In order to evaluate the VoLL related to inadequacy for each category of consumers, the RA shall specify the characteristics of outages caused by inadequacy in terms of:
    a. duration(s);
    b. most likely period(s) of occurrence (hour, week day or week-end, season of the year);
    c. pre-notification period[3] (indicating if there is a pre-notification and, if there is one, how long it is).

Article 5
VoLL for domestic and tertiary sector

1. To evaluate the VoLL for domestic consumers and the tertiary sector, the RA shall conduct surveys separately for domestic sector (private households) and tertiary sector (SME and public sector). If recent surveys (less than 5 five years before the determination of the single estimate of VoLL in accordance with the CEP regulation) have been conducted following the methodology presented in this document, the RA may use the results of the surveys.
    a. The surveys shall select a representative sample and apply appropriate statistical processing operations to the output data.
    b. The surveys shall use the contingent valuation methodology and ask "Willingness to Accept" questions describing the characteristics of outages caused by adequacy issues decided in Article 4.
    c. To convert VoLL for both sectors separately expressed in EUR/outage into VoLL expressed in EUR/MWh, the RA shall estimate the amount of electricity cut off during the outage, by estimating the electrical consumption of the interviewee corresponding to the outage scenarios that are evaluated. In order to do so, questions about annual consumption and use of standardised consumption profiles should be asked at the beginning of the surveys.

[3] For example, a pre-notification period of 8 hours means that consumers suffering an outage had been warned 8 hours in advance that they might be cut off from the grid and how long it would last. In order to lower the impact of adequacy issues, it is recommended that Member States establish procedures to communicate such information to the consumers.

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Article 6
VoLL for the industry

1. The VoLL for the industry sector is the sum of two cost categories, as defined in the equation below:

$$VoLL\ (sector) = Lost\ Production\ (sector) + other\ costs\ (sector)\ [\text{EUR/MWh}]$$

Where other costs can encompass damage costs, restart costs, discomfort (e.g. lack of light), injuries caused by the outage, capacity utilisation, working costs, costs of lost materials or productions, impact on final consumers and on the rest of the society, etc.

2. To evaluate the value of the lost production for each industry sector, which is supposed to be independent from the time and duration of the outage, the RA shall conduct a macro-economic evaluation defined by the equation below:

$$Lost\ Production\ (sector) = PNF \cdot SF \cdot \frac{Annual\ gross\ value\ (sector)}{Annual\ electricity\ consumption\ (sector)}\ [\text{EUR/MWh}]$$

Where:

- *PNF* is the pre-notification factor (see paragraph 3).
- *SF* is the substitutability factor which represents the proportion of gross value added that is reliant on the supply of electricity. This factor was estimated to be 68% for agriculture, forestry and fishing and 80% for the other industrial sectors in a study[4] commissioned by ACER. This value shall either be used directly or re-assessed by the RA if judged necessary, in particular if the value is not updated in the future.
- The annual gross value of the respective sector can be obtained from Eurostat database [nama_10_a64] or from national statistical office.
- The annual electricity consumption of the respective sector can be obtained from Eurostat database [nrg_105a] or from national statistical office.

3. If no pre-notification is given in case of adequacy issues (see Article 4), PNF = 100%. If a pre-notification is given, the impact shall be taken into account either by running an appropriate survey or by using the results from ACER study[1]: 62% for agriculture, forestry and fishing and 79% for other industrial sectors.

4. The value due to the lost production is generally the main cost component of the VoLL for industry. The choice of estimating the other costs mentioned in the paragraph 1 is left to the RA: if the RA estimates that other costs such as restart costs are significant for some industries of its bidding zone and shall therefore be estimated, the RA shall conduct dedicated surveys using the direct worth methodology, with the parameters specified in Article 4. If the RA estimates that those costs will have a negligible impact on the final estimation of VoLL, the RA can estimate those being equal to 0.

[4] ACER "STUDY ON THE ESTIMATION OF THE VALUE OF LOST LOAD OF ELECTRICITY SUPPLY IN EUROPE", 6 July 2018 (link)

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Article 7
VoLL for the transport sector

1. In this Article, the transport sector includes public transport of passengers (e.g. trains, electric public transportation in cities).

2. VoLL for the transport sector is defined as:

$$VoLL\,(transport) = Lost\ Production\,(transport) + other\ costs\,(transport) + Value\ of\ lost\ time\ \text{[EUR/MWh]}$$

To evaluate the VoLL for the transport sector, the RA shall therefore first evaluate the value due to the lost production, and other costs if relevant, as described in Article 6.

3. In addition, the value of lost time for the passengers should be estimated. For each hour of outage, the value of time lost in public transport can be expressed as:

$$Value\ of\ lost\ time = \frac{NPh\ \cdot hourly\ value\ of\ time}{Hourly\ power\ consumption\ of\ the\ type\ of\ public\ transport}\ \text{[EUR/MWh]}$$

Where

- *NPh* is an estimation of the number of passengers at each hour (see paragraph 4).
- The hourly value of time shall be valued at the wage rate for employed people and 50% of wage rate for unemployed. Both the hourly wage and share of employed people can be obtained from Eurostat database.

4. The number of passengers at each hour (NPh in paragraph 3 above) shall be calculated using the following formula:

$$NPh = \frac{NPa \cdot average\ duration\ of\ one\ journey}{8760}\ \text{[passengers/h]}$$

Where

- *NPa* is the annual number of passengers in the concerned type of public transport.
- Data about passenger frequentation shall be obtained from Eurostat or national statistics.

Article 8
Single VoLL estimate

1. After evaluating the VoLL of each category (Articles 5, 6 and 7), the RA shall calculate the single estimate of VoLL related to adequacy issues for his bidding zone. The single VoLL estimate should represent the most likely cost of an adequacy outage, during which the different categories of consumers may be affected in different proportions. The RA shall therefore specify which of the categories and sub-categories (among domestic, tertiary, industry and transport) are likely to suffer from an adequacy outage and the weight of each of these categories in the total EENS.

2. In that regard, the single VoLL estimate shall be calculated as the "expected energy not served"-weighted average of the values of the different categories of consumers:

$$VoLL = \sum_i VoLL_i \cdot \omega_i$$

where the weights ω_i represent the proportion of each category in the total EENS:

- By default, the weight ω_i would be equal to

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- the power consumption ratios per sector *i* during expected daily peak times of demand, which should correlate with moments of scarcity, for the categories of consumers who may suffer adequacy outages,
- zero for the categories of consumers not concerned by outages during adequacy situations. In particular, price-elastic consumers that are not considered to suffer EENS – as they are considered as DSR – in the resource adequacy assessments should be excluded from the single VoLL estimate calculation.

- If relevant, those weights ω_i could be further calibrated following the logic of the load shedding plans in place in Member States to deal with adequacy crisis. For example, if there are priority consumers (e.g. hospitals) who may not be targeted during rotating load shedding plans, their weights may be adjusted to zero.

TITLE 3
Calculation of the Cost of New Entry

Article 9
Overview of the calculation of the Cost of New Entry

1. When applying Capacity Mechanisms, Member States shall calculate a single estimate of the gross CONE for generation, or demand response, for their territory. That estimate shall be made publicly available. Member States may determine one estimate per bidding zone if they have more than one bidding zone in their territory. Where a bidding zone consists of territories of more than one Member State, the concerned Member States shall jointly determine a single estimate of the cost of New Entry for that bidding zone.
2. Member States shall update their estimate of the Cost of New Entry at least every five years, or earlier, where they observe a significant change. When calculating the Cost of New Entry, each Member State shall apply the principles set out in paragraph 3[5].
3. The following steps shall be performed in order to calculate the Cost of New Entry:
   a. Review and select potential candidate technologies that can be considered as Reference Technologies;
   b. Define the detailed technical characteristics of the candidate Reference Technologies;
   c. Develop a bottom-up estimate of Capital Costs and Annual Fixed Costs for each candidate reference technology;
   d. Determine an appropriate Cost of Capital for each candidate Reference Technology;
   e. Compute the Equivalent Annualized Costs (EAC) of each candidate Reference Technology and determine the final Cost of New Entry.
4. These tasks shall be performed based on transparent, reliable, objective and verifiable sources and criteria.

[5] As an illustration, Member States may refer to the CONE estimate made by Pöyry for the Irish Regulator (https://www.semcommittee.com/sites/semc/files/media-files/SEM-18-025a%20Cost%20of%20New%20Entrant%20Peaking%20Plant%20and%20Combined%20Cycle%20Plant%20in%20I-SEM_FINAL.pdf) or by The Brattle Group for AESO the Alberta Electric System Operator (https://www.aeso.ca/assets/Uploads/CONE-Study-2018-09-04.pdf)

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Article 10
Review and selection of candidate Reference Technologies

1. Member States shall identify candidate Reference Technologies for the purpose of the calculation of the Cost of New Entry. Candidate Reference Technologies shall reflect technologies for which investment decisions are likely to be made by rational and competitive investors in Member States. Candidate Reference Technologies can be either generation capacity, storage facilities or Demand-Side Response resources. Member States shall define the Candidate Reference Technologies based on the criteria set out in paragraph 3

2. For avoidance of doubt, selection of candidate Reference Technologies is independent of the identification of capacity eligible to participate in the Capacity Mechanism, where such mechanisms exist or are planned. A technology can be excluded as a candidate Reference Technology to determine the CONE but be nevertheless eligible for the Capacity Mechanism if it meets eligibility criteria defined by Member States or a competent authority.

3. The candidate Reference Technologies shall respond to the following three criteria:

   a. **Merchant technology.** A candidate Reference Technology shall be merchant. To verify whether a given technology is merchant, the Member State should demonstrate that it does not benefit from a legal State Aid, with the exception of the State aid for adequacy objective, i.e. Capacity Mechanism.
   b. **Standard technology.** A candidate Reference Technology shall be identified as standard. To identify whether a given technology is standard, the Member State should demonstrate that a) reliable and generic cost information is available for cost components defined in Article 14, b) the costs of building and operating of the technology do not vary significantly from one project to another and c) development of these technologies is not significantly bound by technical constraints. Technologies with limited capacity which can be aggregated in homogeneous clusters shall be considered as standard if reliable data is available to characterise each cluster. Reliable data might consist of cluster capacity, cluster activation price and economic and/or technical activation constraints representative of the cluster.
   c. **Potential new entry.** A candidate Reference Technology shall be based on potential new entry. To demonstrate that the candidate Reference Technology is representative of possible capacity additions in the coming years, the Member States should demonstrate that a) capacity representing this technology has been developed in the recent past, is in process of development or is planned for development in the near future and b) future development of this technology is not significantly bound or banned by the national or European energy policy.

4. Criteria shall be assessed based on country-specific and up-to-date information from industry experts, competent authorities and stakeholders, studies and literature search or opinions of external consultants. At least one candidate reference technology shall be defined for each Member State.

Article 11
Define the detailed technical characteristics of the selected reference technologies

1. For each candidate Reference Technology, its technical specifications shall be determined based on the most likely choices that developers will make (or have made in recently built or planned units). Only technical specifications which are expected to have an impact on cost estimates defined in Article 14 and the De-rated Capacity estimation defined in Article 12 shall be defined. These specifications may include the following, where applicable:

   - plant type and configuration,
   - fuel type and the fuel supply specifications,

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- the nominal capacity of energy generation or load reduction,
- constraints on continuous energy production or load reduction (e.g. storage capacity or maximum number of activations),
- types of consumers that can reduce their consumption in the context of demand response,
- the electricity network level to which the plant is connected,
- the fuel supply network to which the plant needs to be connected,
- the environmental requirements and the investment needed to comply with them,
- the location.

2. These specifications shall be made as far as possible on (i) preference estimates by investors, based on recently built or planned projects in the territory of the Member States or in similar countries, and (ii) expectations on future underlying economics, regulation and infrastructure. Data sources may include information provided by operators, information from industry experts, databases and modelling software, studies and literature research, expertise from consultants or competent stakeholders.

Article 12
De-rated Capacity

1. Member States shall determine a De-rated Capacity (in MW) for each candidate Reference Technology. A De-rated Capacity shall reflect the statistical degree to which the installed capacity of the candidate Reference Technology is available to provide output in times of System Stress.
2. The De-Rated Capacity should be calculated using the data on technical characteristics presented in Article 11, as well as the available and reliable information on operation of the Reference Technology. In particular, this calculation should reflect:
    a. Forced outages or any other relevant outage during Stress Events (e.g. planned maintenance if relevant or long lasting unavailability); and
    b. Energy and activation constraints during the Stress Events.
3. Given that Reliability Standard presented in Article 17 and Article 18 will indirectly depend on the De-rated Capacity, to avoid potential circularity issues, the calculation of the De-rated Capacity should be based on the assumption of a system that is compliant with any previously existing reliability standard. However, the validity of De-rated Capacity calculated under such assumption shall be carefully monitored. In case the observed De-rated Capacity derived from EERA and/or relevant national studies deviates significantly from the one previously calculated to define CONE under the above-mentioned assumption, an update of the corresponding De-rated Capacity and hence on the corresponding value of CONE might be justified.
4. Where a Capacity Mechanism exists or is planned for implementation and De-rated Capacity is calculated for the purpose of the Capacity Mechanism, the Member State shall verify and ensure consistency of the De-rated Capacity used in the context of this Methodology and the De-rated Capacity used for the purpose of the Capacity Mechanism.

Article 13
Construction Period and Economic Lifetime

1. Member States shall define the Construction Period (in years) for each candidate Reference Technology. Construction Period shall represent the number of years and months between the investment decision and the time when the capacity resource is operating.

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2. Member States shall define the Economic Lifetime (in years) of each candidate Reference Technology. Economic Lifetime shall represent the period over which the initial capital investment is expected to be recovered by rational investors.

Article 14
Development of bottom-up estimates of Capital Costs and Annual Fixed Costs for each candidate Reference Technology

1. Member States shall estimate the Capital Costs and Annual Fixed Costs for each candidate Reference Technology, whereas:
    - Capital Costs refer to all costs incurred during the Construction Period, before the commercial online date; and
    - Annual Fixed Costs refer to costs incurred each year once the capacity resource starts operating and which do not depend on the generated volume.
2. Member States should assess the Capital Costs including all costs incurred during the Construction Period, until the commercial online date of the capacity resource. Member States shall also define the yearly cash flows associated with Capital Costs during the Construction Period.
3. The cost elements considered as part of the Capital Costs may include but not be limited to:
    - Contractor's costs, including (where applicable and relevant) equipment, construction labour, materials, contractor's fees, contractor's contingency, and
    - Owner's costs, including (where applicable and relevant) project development costs, costs incurred during the testing phase prior to operation, electrical interconnection costs, gas or other fuel network connection costs, financing fees, owner's contingency, measurement and control technology, software and communication technology, and cost of land.
4. Member States should define the Annual Fixed Costs of the candidate Reference Technologies on a yearly basis, for each year after the commercial online date and during the Economic Lifetime. Elements of the Annual Fixed Costs may include (where applicable and relevant) but not be limited to:
    - Labour costs;
    - Maintenance and repair costs;
    - Insurance and asset management costs;
    - Property tax;
    - Transaction and control costs;
    - Annual fixed costs of the underlying load curtailed industrial processes;
    - Fuel supply service contracts (excluding the fuel costs); and
    - Electric transmission charges.
5. Costs shall be assessed by Member States considering technical specifications determined according to Article 11, considering as much as possible country-specific prices, characteristics and requirements, and shall be based on transparent, reliable and verifiable sources.
6. All costs shall be expressed in the local currency and in real terms.
7. Data sources used for the definition of the Capital Costs and Annual Fixed Costs may include: information provided by operators, information from industry experts, industry databases, studies and literature research, expertise from consultants or competent stakeholders.

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Article 15
Determine an appropriate Cost of Capital

1. Member States shall determine the Cost of Capital, referred to as WACC (Weighted Average Cost of Capital) to be used to calculate Equivalent Annualized Costs (EAC), referred to in Article 16.
2. WACC calculated by a Member State should be applicable in its territory for a merchant investor investing in the candidate Reference Technology. It shall represent the minimum rate of return required by fund providers (shareholders and/or creditors) to finance investment in the Reference Technology in the Member State and shall be based on transparent market data.
3. Member States can use the same WACC for all candidate Reference Technologies. However, if relevant and if data is available, Member States may calculate a different WACC for each candidate Reference Technology or specific groups of Reference Technologies.
4. If WACC estimates are already available, Member States may rely on them to the extent that they are relevant to their territory, recent and representative of the minimum rate that a merchant investor would require to invest in the candidate Reference Technologies.
5. If no relevant value is available, Member States shall calculate a new WACC value. To this end, they can rely on the guidelines presented in the following paragraphs.
6. However, Member States shall keep in mind that there is not a unique way to define WACC and its components and that WACC is often a result of a combination of data and judgement to account for each country's and industry's specificities. The final decision on the principles followed to compute the WACC is left to each Member State, provided that this decision is based on transparent, reliable, objective and verifiable sources and criteria.
7. A pre-tax real WACC can be calculated, according to the following formula:

$$WACC_{\text{pre-tax}} = \frac{1 + \left[CoE \cdot \frac{1-g}{1-t} + CoD \cdot g\right]}{1+i} - 1$$

where:

- (CoE) represents the Cost of Equity, as defined in paragraph 8;
- (CoD) represents the Cost of Debt, as defined in paragraph 13;
- (g) represents the Gearing, as defined in paragraph 15;
- (t) corresponds to tax rate, as defined in paragraph 16; and
- (i) represents the long-term inflation rate of the Euro zone.

8. The Cost of Equity can be expressed as:

$$CoE = r_f + \beta \cdot ERP + CRP$$

where:

- (r_f) represents the Nominal Risk-free Rate, as defined in paragraph 9;
- (ERP) corresponds to the Equity Risk Premium, as defined in paragraph 10;
- (β) is the Equity Beta, as defined in paragraph 11; and
- (CRP) corresponds to the Country Risk Premium, as defined in paragraph 12.

9. The Nominal Risk-free Rate shall reflect the return an investor would expect from a relatively safe investment, such as government securities. For all Member States, Risk-free Rate shall be determined

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based on average past yield observations of the Eurozone country with the best credit rating. Maturity of bonds shall be consistent with the Economic Lifetime of each candidate Reference Technology and be liquid enough to provide representative results.

10. The Equity Risk Premium shall measure the extra return that is required by investors for shifting their money from a risk-free investment into a diversified equity portfolio. Several approaches can be used to estimate this Equity Risk Premium (historical data, estimated based on forecasts or survey results). Member States may refer to the following widely used and recognised sources to define the Equity Risk Premium: Dimson/Marsh/Staunton (DMS) data, Credit Suisse, Damodaran, Fernandez's survey. In any case, Member States shall ensure that assumptions made to calculate Equity Risk Premium are consistent with choices made to define the Risk-free Rate.

11. Equity Beta is a measure of the relative risk of the investment compared to the market as whole. It can be inferred from capital market evidence for Peer Companies based on the following steps:

    - Peer Companies shall be determined: they must be publicly traded, have characteristics similar to a potential firm investing in the candidate Reference Technology and be exposed to the same systematic risk (comparable business line, region, size, risk profile…);
    - For each Peer Company, a raw beta shall be determined by the use of regression techniques based on historical data;
    - Member States may apply an adjustment to the calculated raw beta to improve the accuracy of the final estimation (e.g. based on the Blume adjustment);
    - Member States shall un-lever the Equity Beta of each firm by determining its asset beta (for instance based on the Hamada formula). Then the average asset beta over the peer group shall be converted into Equity Beta using the Gearing value defined according to paragraph 15.

12. For each Member State, the Country Risk Premium measures the additional premium on equity that a company investing in the Member State would require compared to an identical firm investing in the country used to define the Risk-free Rate according to paragraph 9. Country Risk Premium can be computed based on additional default premium required by investors to hold bonds in the Member State, compared to the reference country's bonds, or based on values provided in the literature (e.g. Damodaran).

13. The Cost of Debt can be determined as:

$$CoD = r_{\mathrm{f}} + D_{\mathrm{p}}$$

where:

- (r_{f}) represents the nominal Risk-free Rate, defined according to paragraph 9;
- (D_{p}) represents the debt premium, defined according to paragraph 14.

14. Debt premium represents the expected compensation of creditors of investments of a specific risk category compared to a risk-free investment. Debt premium can be determined based on (i) spread of publicly traded debts from Peer Companies which are likely to invest in the candidate Reference Technology (when debt has been raised), or (ii) default spread associated with credit ratings of Peer Companies which are likely to invest in the candidate Reference Technology (default spread based on credit ratings are provided by credit agencies or by Pr. Damodaran of the University of New York). In any case, maturity of debts considered to define the debt premium shall be consistent with maturity considered for risk-free calculation according to paragraph 9 and with the Economic Lifetime of the candidate Reference Technology.

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15. Gearing refers to the proportion of debt in the total asset value. Gearing shall be determined based on observable Gearing for publicly traded companies which are likely to invest in the candidate Reference Technology.

16. The Tax Rate shall represent the corporate income tax rate applied in the Member State for companies which are likely to invest in the candidate Reference Technology.

17. In case a Member State has a currency different from the Euro, the WACC computed according to paragraph 7 can be corrected according to the following equation so that it can be applied to cash flows expressed in local currency:

$$WACC_{local\ currency} = (1 + WACC_{\text{Euro}}) \cdot \frac{1+j}{1+i} - 1$$

Where:

- $WACC_{\text{euros}}$ represents the WACC computed according to paragraph 7;
- i corresponds to long term inflation rate estimate of the local currency; and
- j corresponds to long term inflation rate estimate of the Euro zone.

Article 16
Compute the Equivalent Annualized Costs and determine the CONE

1. For each candidate Reference Technology, Capital Costs and Annual Fixed Costs incurred over the Construction Period and Economic Life of the plant shall be translated into Equivalent Annualized Costs (EAC). EAC is defined as a constant annual payment over economic lifetime for which the Net Present Value is equivalent to that of a cash flow represented by the Capital Costs and Annual Fixed Costs over the Construction Period and the Economic Lifetime. The EAC is defined by the following formula:

$$\sum_{i=1}^{X} \frac{CC(i)}{(1+WACC)^i} + \sum_{i=X+1}^{X+Y} \frac{AFC(i)}{(1+WACC)^i} = EAC \sum_{i=X+1}^{X+Y} \frac{1}{(1+WACC)^i}$$

2. From the formula in 1, the EAC is derived as:

$$EAC = \left[\sum_{i=1}^{X} \frac{CC(i)}{(1+WACC)^i} + \sum_{i=X+1}^{X+Y} \frac{AFC(i)}{(1+WACC)^i}\right] \cdot \frac{WACC \cdot (1+WACC)^{X+Y}}{(1+WACC)^Y - 1}$$

Where:

- i represents each year over the Construction Period and Economic Lifetime;
- X is the Construction Period (in years) defined according to Article 13;
- Y is the Economic Lifetime, defined according to Article 13;
- $CC(i)$ are the Capital Costs incurring each year of the Construction Period, defined according to Article 14;
- $AFC(i)$ are the Annual Fixed Costs incurring each year during the Economic Lifetime, defined according to Article 14; and
- $WACC$ is the Weighted Average Cost of Capital as defined in Article 15.

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3. The Cost of New Entry for a given candidate Reference Technology should be calculated as the ratio between the Equivalent Annualised Costs and the De-rated Capacity:

$$CONE = \frac{EAC}{K_{\mathrm{d}}}$$

Where:

- EAC represents the Equivalent Annualised Costs of a given candidate Reference Technology calculated according to the formula mentioned in paragraph 2.
- K_{d} represents the De-rated Capacity of the candidate Reference Technology, defined according to Article 12.

4. If the candidate Reference Technology with the lowest CONE has no capacity limit, the final CONE shall be defined as the lowest CONE across the candidate Reference Technologies.

5. If the candidate Reference Technology with the lowest CONE has a capacity limit, a capacity need shall be defined for the period studied. The capacity need shall be based on analysis from the latest adequacy assessments at regional, national or Union level (e.g. based on the relation between observed number of hours with EENS and capacity margins of the electric system). The final CONE shall be defined as the lowest CONE (c) across candidate Reference Technologies verifying the following condition: the sum of the capacity limits of candidate Reference Technologies with a CONE equal or lower than the CONE (c) is higher than the capacity need as referred above. If a candidate Reference Technology with a CONE equal or lower than the CONE (c) has no capacity limit the condition is automatically respected.

6. In case the candidate Reference Technology with the lowest CONE has a capacity limit, the consistency between the capacity need used above and the capacity need resulting from the calculation of the Reliability Standard (Title 4) shall be verified. The capacity need used above shall be adjusted until consistency is achieved.

TITLE 4
Calculation of the Reliability Standard

Article 17
Main Reliability Standard based on Loss of Load Expectation

1. According to IEM Regulation Article 25 (1), when applying Capacity Mechanisms Member States shall have a Reliability Standard in place.

2. Member States shall calculate a single Reliability Standard for their territory. Member States may determine one Reliability Standard per bidding zone if they have more than one bidding zone in their territory. Where a bidding zone consists of territories of more than one Member State, the concerned Member States shall jointly determine a single Reliability Standard for that bidding zone.

3. The Reliability Standard shall express the optimal level of security of supply, found when the incremental cost of additional capacity insuring customers against load curtailments is equal to the incremental cost of load curtailments to customers. When considering this social perspective, costs shall be considered to determine the Reliability Standard.

4. Before proposing a Reliability Standard to the relevant Member State or competent authority designated by the Member State, as referred in IEM Regulation Art 25 (2), the National Regulatory Authority shall coordinate with neighbouring National Regulatory Authorities, in order to assess any risk related to non-harmonized Reliability Standards among their respective Member States.

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5. The Main Reliability Standard shall be expressed as a target Loss of Load Expectation. The Main Reliability Standard shall be derived from the Value of Lost Load calculated according to TITLE 2 of the present Methodology and the Cost of New Entry calculated according to TITLE 3 of the present Methodology.

6. Member States shall update their Main Reliability Standard after each update of the Value of Lost Load and/or of the Cost of New Entry.

7. The Main Reliability Standard expressed in terms of a target LOLE should be calculated according to the following formula:

$$LOLE_{\text{target}}\ (\text{h}) = \frac{CONE\ (local\ currency/\text{MW})}{VOLL\ (local\ currency/\text{MWh})}$$

8. The Main Reliability Standard expressed in terms of a target $LOLE_{target}$ and calculated according to the formula in paragraph 7 above would ensure an optimal level of security of supply determined by the point at which the incremental cost of additional capacity insuring customers against load curtailments (CONE) is equal to the incremental cost of load curtailments to customers (incremental volume of Expected Energy Not Served expressed as LOLE, valued at VOLL).

9. To assess whether the Main Reliability Standard is achieved, the Member State shall assess its expected LOLE in a specific forward time frame according to the Resource Adequacy Methodology presented in IEM Regulation Article 23 and compare it with the target $LOLE_{target}$ presented in paragraph 7 above.

10. The Main Reliability Standard shall be considered satisfied if the expected LOLE, for a given year, is lower than the target $LOLE_{target}$.

Article 18
Conditions of Validity of the Reliability Standard definition

1. According to IEM Regulation Article 25 (3), the Reliability Standard *"shall be expressed as 'expected energy not served' and 'loss of load expectation'"*. Contrary to the Main Reliability Standard expressed in terms of a target LOLE according to the formula provided in paragraph 7, there is no economic justification for a reliability target based on the total value of EENS. An economically optimal Reliability Standard should rely on the incremental variation of EENS (*i.e.* the LOLE) and not the total EENS. For the same LOLE target, EENS may vary significantly depending on the supply/demand characteristics.

2. In absence of an economically justified target level of EENS, ENTSO-E recommends to use a reliability standard based solely on LOLE as defined in Article 17.

3. The derivation of the Main Reliability Standard (Article 17) reflects an economic optimization between the marginal cost of a "best new entrant" asset (CONE) and the marginal reduction of EENS (LOLE*VOLL). The optimum is reached when these two quantities are equal.

   This economic optimality theory is valid under various assumptions:

   i. The marginal reduction of EENS can be expressed in terms of LOLE, i.e., the following formula holds:

$$\frac{dEENS[Q]}{dQ} = -LOLE$$

   In particular, this assumption holds if:

   - no energy constraint affects capacities of the electric system, or

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- energy constraints are properly represented through the de-rating modelling introduced in Article 16(3) and the Q capacity mentioned in the formula above represent certified quantities (i.e. installed capacity multiplied by the de-rating factor K_d).

ii. Near the optimal, the marginal cost of capacity is mainly determined by the fixed cost of the units.

iii. New capacity is required in order to reduce EENS.

iv. EENS is only reduced in the concerned country.

The validity of these assumptions should be monitored. If the validity assumptions are not met, corrections to the above definitions might be necessary (We refer to Appendix 1 in the document).

TITLE 5
Final provisions

Article 19
Implementation

1. Member States shall apply the proposed Methodology as described in Titles 1 to 4 to support their application for a Capacity Mechanism.

Article 20
Language

1. The official language for this Methodology shall be English. For the avoidance of doubt, where TSOs need to translate this Methodology into their national language(s), in the event of inconsistencies between the English version published by Member States and any version in another language, the relevant Member State shall be obliged to dispel any inconsistencies by providing a revised translation of this Methodology to their relevant national regulatory authorities.

Appendix 1

1. If assumptions described in article 18(3) are not met, corrections might be applied to the formula described in article 17(7).

   For each assumption, possible corrections are as follows:

   i. Where peaking units are energy constrained (e.g. DSR, batteries or other types of storage), the consistency between the determination of the de-rating factor used in the definition of CONE and the marginal reduction EENS, $\frac{dEENS[Q]}{dQ}$ shall be thoroughly verified.

   ii. In electric systems where new capacity brings a non-negligible reduction in costs C for demand and supply adequacy, other than fixed and investment costs, and in addition to its contribution to the reduction of EENS (e.g. batteries operating on the energy market), a revision of the previous formula for Reliability Standard presented in Article 17 and Article 18 might be justified as:

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$$LOLE = \frac{CONE - dC/dQ}{VOLL}$$

, where C is equal to costs for demand and supply adequacy, other than fixed and investment costs.

iii. In countries where renewal/prolongation of already existing capacities is sufficient to reach the economic optimum mentioned above (e.g. in case of consumption decrease), the Cost of Renewal/Prolongation (CORP) shall be considered instead of CONE. The principles used to calculate the CORP value shall be derived from the principles described in Title 3 for the calculation of CONE. In particular, methodological steps described in Article 11 to 16 shall be applied. The consistency between the CORP value and the costs resulting from the new Reliability Standard (Title 4) shall be verified. The CORP value chosen shall be adjusted (up to the CONE value) until consistency is achieved.

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