EJENS
European Journal of Engineering and Natural Sciences
e-ISSN : 2458-8156

Review of the reliability standards in EU electric power system

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Abstract

Security of supply is one of the main objectives of a comprehensive package of EU legislative acts called Clean Energy for All Europeans. Through these legislative acts, the EU aims to accelerate the deployment of clean technologies, increase market competitiveness and energy efficiency, outline the design of the electricity market and security of supply, and create new rules for the governance of the Energy Union, making the European electricity market more interconnected, flexible and consumer-oriented.

One of the main objectives is to determine the most efficient and effective way to ensure appropriate adequacy of generation units in the EU. In October 2020, European Union Agency for the Cooperation of Energy Regulators (ACER) presented the Methodology for calculating the value of lost load, the cost of new entry, and the reliability standard, which specifies the security of supply indexes and define the methodology for their calculation.

Therefore, each EU Member State has to determine the value of lost load (*VOLL*), the cost of new entry (*CONE*) for different candidate technologies that are able to provide resource adequacy benefits (generation, storage and demand side response), and the reliability standard that consists of expected energy not served and loss of load expectation.

The paper provides an overview of the methodology and results for countries that have already defined reliability standards according to the new methodology.

Key words

Cost of new entry for generation or demand response (*CONE*), Expected energy not served (*EENS*), Loss of load expectation (*LOLE*), Value of lost load (*VOLL*)

1. INTRODUCTION

The primary task of a transmission system operator is the power transmission, where the reliability of the power system is important. The most important factor in reliability is the continuity of supply of the final customers. Security of supply is also one of the objectives of the publication of a comprehensive package of legislative acts called Clean Energy for All Europeans [1]. Article 25 of the regulation provides that Member States have to draw up a reliability standard based on the methodology referred to in Article 23(6).

The reliability standard shall set out in a transparent manner the required level of security of supply to the Member State determined as the most efficient and effective way to ensure appropriate adequacy of generation units in the

EU. The reliability standard is calculated using at least the value of the lost load (*VOLL*) and the cost of new entry (*CONE*) and is expressed as expected energy not served (*EENS*) and loss of load expectation (*LOLE*). Thus, the *LOLE* indicator reflects the economic optimization between the cost of new entry (*CONE*) and the marginal reduction in expected electricity not served (*EENS*), expressed as the product of *LOLE* × *VOLL*.

In October 2020, European Union Agency for the Cooperation of Energy Regulators (ACER) presented the document Methodology for calculating the value of lost load, the cost of new entry, and the reliability standard, which specifies the security of supply indexes and define the methodology for their calculation [2]. Under Regulation (EU) 2019/943, Member States have started activities in the field of defining the reliability standard. The activities were started mainly by countries that already had reliability standards defined before the adoption of the regulation.

Therefore, the methodology for calculating the reliability standards will first be presented and followed by an overview of the reliability standards per Member State.

2. METHODOLOGY FOR CALCULATING THE RELIABILITY STANDARDS

Methodology for calculating the value of lost load, the cost of new entry, and the reliability standard [2], describes how to calculate:

- the *VOLL*,
- the *CONE* and
- the reliability standard.

General rules for determination of all three indicators are:

- The entity calculating the *VOLL*, *CONE* and reliability standard shall update the calculation at least every five years, or earlier, where the entity observes a significant change.
- The entity has to ensure that the procedure is based on transparent, objective and verifiable data, the entity shall fulfil the transparency requirements, publishing at least the basic information, that the calculation of the *VOLL*, *CONE* and reliability standard can be repeatable.

However, the rules relating to the determination of each indicator are presented in the following subsections.

2.1. VOLL

In [2], there are specified several rules that must be taken into consideration for determination of *VOLL*. The determination of *VOLL* must be set from the maximum price that consumers are willing to pay to avoid an interruption of electricity supply, obtained from surveys. The structure of the survey is also predefined in the [2]. Based on the answers, the each sectoral *VOLL* for different outages (duration, period of occurrence, pre-notification period) shall be defined. The next step in determination of *VOLL* is a single *VOLL* calculation that will be used in the determination of reliability standard (1).

$$VOLL = \sum_{type} VOLL_{sect,type} \cdot \frac{EENS_{sect,type}}{EENS} \quad (1)$$

where $VOLL_{sect,type}$ is *VOLL* for different sectorial and outages, $EENS_{sect,type}$ is expected electricity not served for different sectorial and outages and *EENS* is expected electricity not served for entire country.

2.2. CONE

In [2], there are also specified several rules that must be taken into consideration for determination of CONE. The following steps shall be performed in order to calculate the CONE:

- Review and select candidate technologies that can be considered as reference technologies and estimate the potential for additional capacity resource.

- Define the detailed technical characteristics of the reference technologies.
- Estimate capital costs and annual fixed costs for each reference technology.
- Determine an appropriate WACC for each reference technology as in (2).
- Compute CONEfixed for each reference technology (3).
- Determine CONEvar for each reference technology.

$$WACC = \frac{1+\left[CoE\cdot\frac{1-g}{1-t}+CoD\cdot g\right]}{1+i} - 1 \quad (2)$$

where *CoE* represents the cost of equity, *CoD* represents the cost of debt, *g* represents the gearing, *t* corresponds to tax rate and *i* represents the long-term inflation rate of the Euro zone.

$$CONE_{fixed} = \frac{\frac{WACC\cdot(1+WACC)^{X+Y}}{(1+WACC)^{Y}-1}\left[\sum_{I=1}^{X}\frac{CC(i)}{(1+WACC)^{i}}+\sum_{I=X+1}^{X+Y}\frac{AFC(i)}{(1+WACC)^{i}}+\right]}{K_d} \quad (3)$$

where *i* represents each year over the construction period and economic lifetime, *X* is the construction period (in years), *Y* is the economic lifetime (in years), *CC(i)* is the best estimate of the capital costs incurring each year of the construction period, *AFC(i)* is the best estimate of the annual fixed costs incurring each year during the economic lifetime, *WACC* is the best estimate of *WACC* and K_d is the de-rating capacity factor of the reference technology.

For each reference new entry, which has a variable cost ($CONE_{var}$) lower than the single *VOLL* the entity shall compute a *LOLE* threshold (4).

$$LOLE_{RT} = \frac{CONE_{fixed}}{VOLL-CONE_{var}} \quad (4)$$

2.3. Reliability standard

The entity shall calculate a *LOLE* target for the reliability standard, based on the *LOLE* thresholds. The *LOLE* threshold reflects an economic optimization between the marginal cost of a new capacity resource (*CONE*) and the marginal reduction of *EENS* (*LOLE* × *VOLL*). The optimum is reached when these two quantities are equal.

The *LOLE* target for reliability standard shall be the minimum (best estimate) *LOLE* threshold which fulfils the minimum capacity need for reliability standard. A minimum capacity need for RS shall be defined based on the results of the latest available national, regional or European resource adequacy assessments (e.g. based on the relation between the observed number of hours with *ENS* and the capacity margins of the electric system). The minimum capacity need for reliability standard shall be lower than (or equal to) the maximum hourly *ENS* observed during the latest European, regional or national resource adequacy assessment [2].

There is no unambiguously defined formula for the calculation of *EENS* in [2].

3. VALUES OF VOLL, CONE AND RELIABILITY STANDARD IN EU

Several countries in EU have already prepared the calculations of *VOLL*, *CONE* in reliability based on previously described rules. These countries are Estonia, Finland, Italy and Sweden. All the countries have determined *VOLL*, *CONE* and reliability standard.

3.1. Estonia

The final report [3] provides an analysis of the *LOLE* value in the case of a gas power plant (OCGT). The value of *VOLL* is estimated at 6,500 €/MWh, 7,300 €/MWh and 8,500 €/MWh, $CONE_{fixed}$ for *OCGT* at 51,000 €/MW,

63,000 €/MW and 78,000 €/MW. Based on the calculations, the value of the *LOLE* is in ranges between 6 hours/year and 12 hours/year, which exceeds the standard of 3 hours/year, so in May 2021 they changed the value of the standard to 9 hours/year. Furthermore, the study also estimated the *EENS* value between 0.053% and 0.087%.

3.2. Finland

Based on the ACER methodology, the value of the *VOLL* for Finland was estimated at 8,000 €/MWh [4]. The calculation of the $CONE_{fixed}$ for various reference technologies is presented, as demand side response (DSR), OCGT, nuclear power plants (NPP), battery storage (BESS), wind power plant (WPP) and solar power plant (SPP). The data are presented in Table 1.

Table 1. $CONE_{fixed}$ for various reference technologies

Technology	$\boldsymbol{CONE_{fixed}}$ **(€/MW)**
DSR	20,000
OCGT	60,000
NPP	537,000
BESS	570,000
WPP	1,583,000
SPP	5,128,000

Based on the data on the *VOLL* and $CONE_{fixed}$, the calculated value of the *LOLE* for determining the reliability standard is defined as 3 hours/year, and the value of the *EENS* as 1,800 MWh per year.

3.3. Italy

In early June, Terna published the study Proposta in merito allo standard di adeguatezza del sistema elettrico italiano [5], in which the calculation for *VOLL*, $CONE_{fixed}$ and *LOLE* was made according to the ACER methodology. Based on the questionnaire, they determined the value of *VOLL*, which amounts to 28,400 €/MWh. The $CONE_{fixed}$ has been defined for different technologies, which are OCGT, combined cycle gas turbine (CCGT), BESS, pumped storage hydropower (PSH), WPP and SPP. The data about $CONE_{fixed}$ are presented in Table 2.

Table 2. $CONE_{fixed}$ for various reference technologies

Technology	$\boldsymbol{CONE_{fixed}}$ **(€/MW)**
OCGT	55,000
CCGT	71,000
BESS	141,000
PSH	200,000

WPP	380,000
SPP	500,000

Based on the calculations, they conclude that the value of *LOLE* according to the ACER methodology is between 2 and 2.1 hours/year and is lower than the value determined by the state.

3.4. Sweden

In May 2021, the Energimarknadsinspektionen (Ei) produced a report Ei:s förslag till tillförlitlighetsnorm för Sverige [6], in which, according to the ACER methodology, *VOLL* is calculated as 7,869 €/MWh and also $CONE_{fixed}$ for different technologies is specified. The data about $CONE_{fixed}$ are presented in Table 3.

Table 3. $CONE_{fixed}$ for various reference technologies

Technology	$\boldsymbol{CONE_{fixed}}$ **(€/MW)**
DSR	3,400
OCGT	19,500
CCGT	62,700
BESS	104,900
PSH	200,000
WPP	1,100,000

Based on the calculations, a value of 0.99 hours/year was set for the *LOLE* as the limit value of the reliability standard, thus covering the highest value of production unit failures from simulations.

4. CONCLUSION

In the paper, a review of the new reliability standard in EU is made. Despite the fact that the new standard has been in force for quite some time, many countries still have not made a calculation according to the new methodology or have not yet made it public. From EU countries, only 4 have made the calculations, which represents 15% of all countries. The main reason for this is attributed to the publication of ERAA results. Based on the ERAA results, just a few countries have a problem with resource adequacy [7].

ACKNOWLEDGMENT

This work was supported by a Slovenian Research Agency as a part of the research program Electric Power Systems, P2–356.

CONFLICT OF INTEREST STATEMENT

The author declares that there is no conflict of interest.

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