Elering Webinar

Adequacy Standard for Estonia

Presentation

5 November 2020

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Introduction

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FTI-CL Energy is the cooperation of energy experts from FTI Consulting and its wholly-owned subsidiary Compass Lexecon, bringing together highly experienced economists, accountants and industry practitioners.

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Focus on our Energy practice	
FTI - Compass Lexecon is one of the leading advisory firms for economic and policy analyses in the European energy industry	Policy and market design
	Investment decision support
	Energy markets modelling
	Financial valuation of assets
	Business model development
	Corporate strategy design
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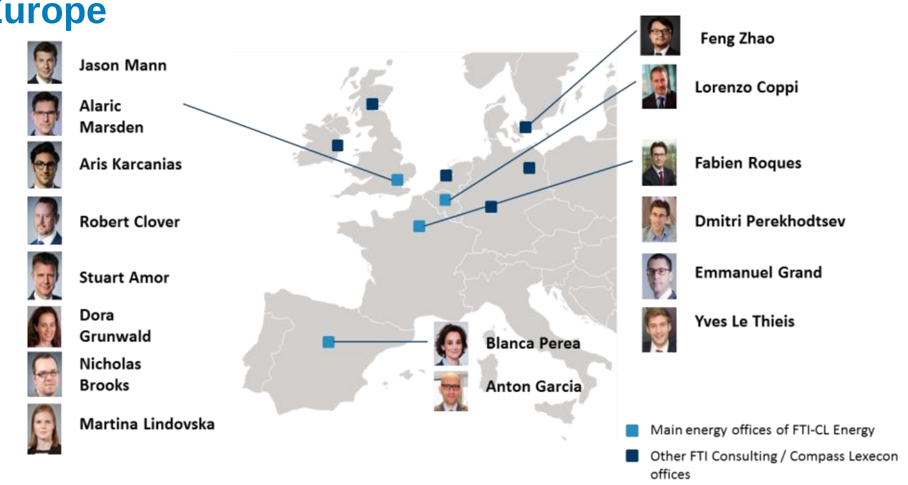
FTI-Compass Lexecon at a glance

FCN Publicly traded – NYSE	$1.4 BLN Market Capitalization
1982 Year founded	80 Different disciplines
4,600+ Employees worldwide	
460+ Senior Managing Directors	
2 Nobel Laureates	
10/10 Advisor to the world's top 10 bank holding companies	

FTI-CL Energy's senior energy experts in Europe



CL ENERGY IS EXPERIENCED IN THE DESIGN OF EUROPEAN CAPACITY MECHANISMS

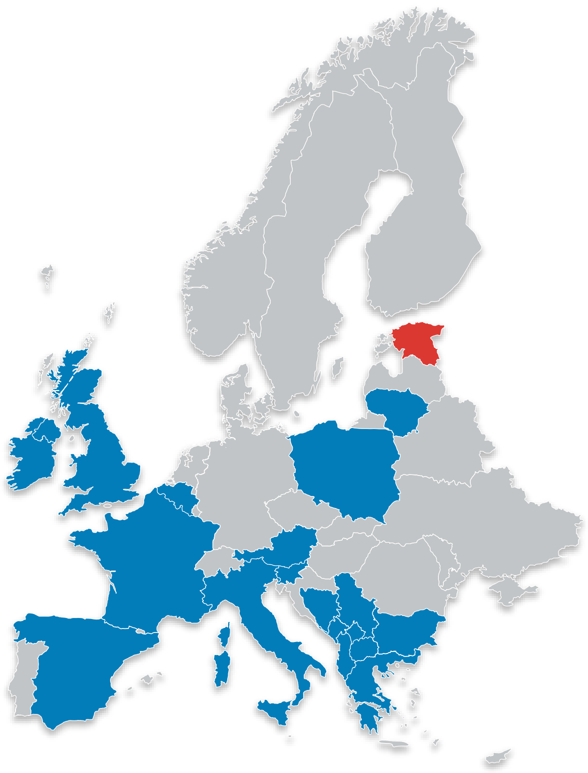
About us

- A global economic consulting firm providing expert economic advice on competition policy, economic and financial regulation, public policy, corporate development and pricing, and the assessment of damages in complex disputes.
- Offices across the US, South America, Asia-Pacific and Europe
- We have the highest number of competition specialists in the industry, with a global team of over 430 professionals and affiliates. 120 in Europe based in Berlin, Brussels, Düsseldorf, Helsinki, London, Madrid and Paris.
- Many former chief economists at competition authorities.
- 145 PhD economists and econometricians, and faculty from leading universities and institutes including two Nobel Prize winners.

Our involvement in Capacity mechanisms design in Europe

Over the last five years, Compass Lexecon has participated in the design and state aid analysis of the Capacity Mechanisms in at least 18 European countries and contributed to the development of the European methodologies for VOLL, CONE and Reliability Standards

European countries where Compass Lexecon worked on Capacity Mechanisms



CONTEXT AND OBJECTIVES OF THE STUDY

EU Regulation 2019/943, a part of the Clean Energy Package, requires Member States to develop **reliability standards** indicating the necessary level of security of supply of the national electricity system following the methodologies that are being developed by ENTSO-E. This includes:

- A methodology for the estimation of Value of Lost Load (Article 11 and Article 23.6);
- The methodology for the assessment of the cost of new entry (CONE) for generators or demand response (Article 23.6); and
- The reliability standards based on Loss of Load Expectation (LOLE) and Expected Energy not Served (EENS) (Article 25).

A dedicated “Adequacy Methodologies” task force within ENTSO-E has prepared drafts of these methodologies and these are now in the process of being reviewed by ACER. The methodologies have been approved by ACER in October 2020.

Elering seeks to establish the Estonian reliability standard for Estonia based on adequacy assessment consistent with the methodologies being developed under EU Regulation 2019-943. Compass Lexecon was mandated as a result of a competitive procurement process (reference No 215657).

Our mission is the following:

- Develop a proposal for the Estonian reliability standard consistent with the EU Regulation
- Draft a report providing thorough justification of the proposed reliability standard
- Run a quantitative analysis of the expected cost to society resulting from deviations from the proposed optimal reliability standard

DEFINITIONS

- **RS - Reliability Standard**
  - A measure of the necessary level of security of supply.
- **EENS (MWh/year) – Expected Energy Not Served**
  - The annual demand 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.
- **LOLE (hours/year) – Loss of Load Expectation**
  - 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.
- **VOLL (EUR/MWh) – Value of Loss of Load**
  - An estimation of the maximum electricity price that customers are willing to pay to avoid an outage.
- **CONE (EUR/MW) – Cost of New Entry**
  - 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.

Most definitions from: https://consultations.entsoe.eu/entso-e-general/proposal-for-voll-cone-and-reliability-standard-me/supporting_documents/191205_Methodology%20for%20VoLL%20CONE%20and%20reliability%20standard_public%20consultation.pdf
VOLL: Regulation (EU) 2019/943

ECONOMIC APPROACH SUGGESTS USING A LOLE TARGET AS A RELIABILITY STANDARD AND NOT EENS

The EU Regulation 2019/943 Article 25 requires the reliability standard to be expressed as:

- Expected energy not served (EENS), and
- Loss of load expectation (LOLE)

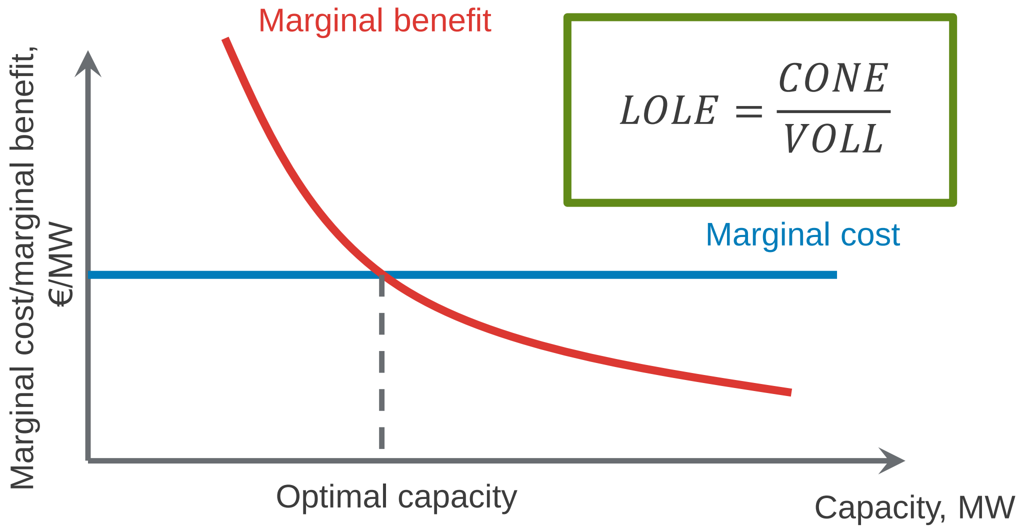
Optimal volume of installed capacity is determined by **maximizing the net social benefit of electricity**:

- Cost of **additional capacity**, and
- Cost of **unserved energy** for customers

The social benefit is maximized in the point where **marginal cost of capacity is equal to marginal benefit**

- **Marginal cost** of capacity is mainly determined by the fixed cost of a MW capacity of peaking units – CONE
- **Marginal benefit** is characterised by the value of the outage avoided by MW of additional capacity – VOLL*LOLE

Economic equilibrium determining the Reliability Standard



$$LOLE = \frac{CONE}{VOLL}$$

RELIABILITY STANDARDS BASED ON LOLE OR EENS OFTEN USED TOGETHER WITH SUPPLEMENTARY REQUIREMENTS

- LOLE is the most widely used Reliability Standard
- EENS is used in Australia and Alberta.
- Along with the main Reliability Standard, a secondary requirement is often used to provide additional security.

International reliability standards based on LOLE and EENS with supplementary requirements

Metric	Main requirement	Supplementary requirement	Jurisdiction
EENS	0.002%	Reserve margin	NEM, Australia
	800MWh – 0.0014%		Alberta, Canada
LOLE	1 in 10 or 2.4 hours		NYISO, PJM, ISO-NE, US
	1 in 10 or 2.4 hours	13.75% reserve margin	ERCOT, US
	3 hours	1 in 10 year winter peak	GB
	3 hours		France, Poland
	3 hours	<20h LOLE 95% of the time in Belgium	Belgium
	4 hours		Netherlands
	8 hours		Ireland
	8 hours	LSI (Load Supply Index)* > 1 in 95% of the time	Portugal

*ratio between the total available power and the hourly peak electricity demand.

Value of Loss of Load

THE VOLL CORRESPONDS TO THE DAMAGE ARISING FROM THE NON-SUPPLY OF ENERGY

The Value of Lost Load (VOLL)

- measures the monetary damage (in €) arising from the non-supply of a given amount of energy (in MWh for instance) due to a power outage, which can be caused by a wide range of technical factors, from lack of generation capacity to networks outages, either on the transmission or on the distribution grid.

VOLL depends on specific parameters

- Customer type
- Duration of interruption
- Time of interruption
- Pre-notification of power interruption

Four main methodologies exist for the VOLL estimation

- Revealed preferences
- Case study
- Stated choice (surveys)
- Macroeconomic

The European methodology for VOLL suggests conducting the surveys for the domestic and tertiary sectors. For the industrial sector, the European methodology considers using the macro-economic approach to estimate the production cost component of VOLL and leaves the decision to RA to assess other outage costs through a survey.

CEPA STUDY SUGGESTS A VOLL OF 3.07€/KWH FOR ESTONIA, BUT THIS IS LIKELY AN UNDERESTIMATION

- CEPA study realised for ACER in 2018(1) using a macro-economic approach provides VOLL estimates by sub-categories of industrial customers, for services customers and for residential customers.
- Matching this with Eurostat data of electricity consumption results in a weighted average VOLL for Estonia of 3.07 €/kWh. However, we consider that VOLL estimation from ACER needs to be corrected because it uses a macro-economic approach that disregards a number of outage costs.

Final electricity consumption by sector and the respective VOLL estimates

Category	VOLL, €/kWh CEPA	Consumption 2018, GWh Eurostat
Basic Metals	2.14	6
Chemical and Petrochemical	0.67	116
Non-metallic Minerals	0.7	194
Food and Tobacco	1	290
Textile and Leather	1.42	61
Paper, pulp and print	0.28	482
Transport equipment	1.48	82
Machinery	2.41	320
Wood and wood products	1.03	539
Construction	10.96	71
Transport	16.1	43
Agriculture, Forestry and Fishing	1.84	165
Domestic	5.18	1860
Services	2.86	2933
Total	3.07	

(1) ACER (2018) "Study on the estimation of the value of lost load of electricity supply in Europe"

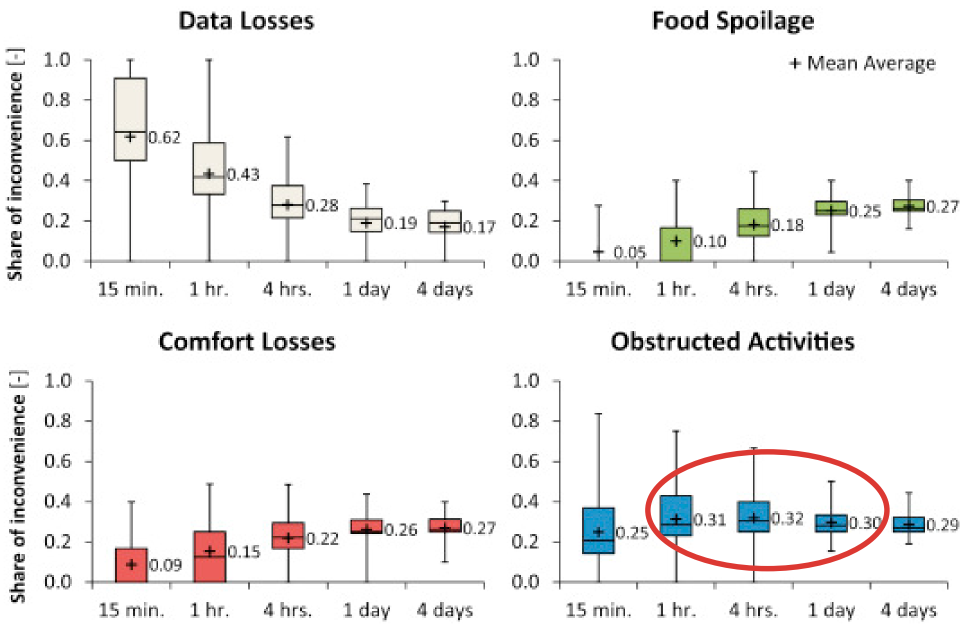
ADJUSTMENT OF THE VOLL VALUE RESULTING FROM MACRO APPROACHES

ACER's approach is based on **two macro-economic indicators** depending on the type of customers: 1. Value of leisure for domestic customers, and 2. Value of production for non-domestic customers. However, both indicators are potentially ignoring significant part of the outage costs.

For the **domestic customers,** Left figure shows the percentage shares of inconvenience caused by power interruptions. However, the value of leisure time (obstructed activities) represents approximately **30-32%** of the domestic outage costs.

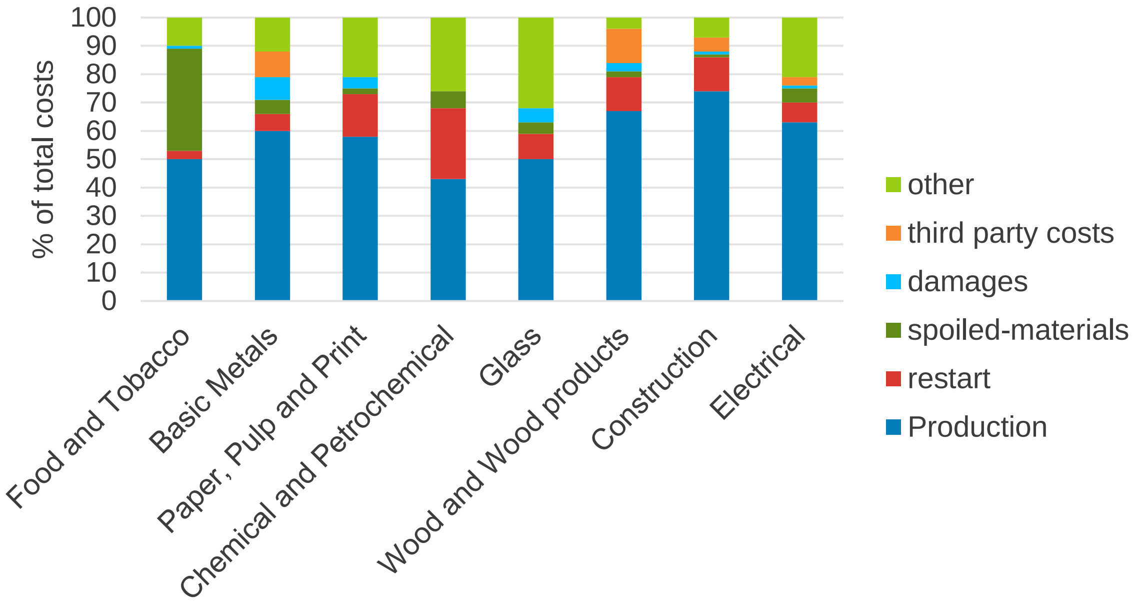
For the non-domestic **industrial sector**, right figure displays the percentage shares of different cost types caused by power outage across industries. The figure highlights that the value of production represents approximately **43-74%** of total outage costs depending on industry.

Percentage shares of outage costs across different loss types and durations for domestic customers



Source: Praktijno (2014) "Stated preferences based estimation of power interruption costs in private households: An example from Germany"

Percentage shares of different outage-related costs across industries



Source: Küfeoğlu, 2015 Economic Impacts of Electric Power Outages and Evaluation of Customer Interruption Costs

VOLL FOR ESTONIA COULD BE ASSESSED IN A RANGE OF 6.5-8.5€/kWh AFTER CORRECTING FOR MISSING COST ELEMENTS

As a starting point, we consider the VOLL of 3.07€/kWh obtained from the ACER's macro-economic study.

We then adjust the VOLL for the outage costs non-accounted for by the macro-economic studies. As mentioned previously:

- VOLL for domestic agents (households) only covers between 30% and 32% of all outage costs
- VOLL for non-domestic agents (industry and services) covers between 43% and 74% of all outage costs

We therefore estimate an adjusted VOLL for Estonia using each sector's weights (% share of total electricity consumption) and the range of correction factors for each sector based on academic literature.

Table below summarizes the correction factors and the corrected VOLL for Estonia, which should range between **6.5 - 8.5 €/kWh.**

Adjusted VOLL for Estonia

Range	Outage costs included in the macro-economic VOLL estimation			Adjusted VOLL (€/kWh)
	Households (26%)	Services (41%)	Industry (33%)	
Low	30%	43%	43%	6.5
Mid	31%	59%	59%	7.3
High	32%	74%	74%	8.5

Cost of New Entry

DERIVING CONE REQUIRES DEFINING REFERENCE TECHNOLOGY

Selection criteria for reference technology, a reminder

- The candidate reference technology has to be **merchant**, **standard**, and based on **potential new entry.**

Top reference technology options for a peaking plant

- **Option 1: OCGT Dual,** natural gas as primary fuel with distillate fuel oil as secondary fuel
- **Option 2: OCGT Distillate,** fuel oil as primary fuel
- **Option 3: Reciprocating Engine** natural gas as primary fuel with distillate fuel oil as secondary fuel**;** Kiisa reference plant: Dual fuel, 250MW, 27 medium-speed 9.7MW engines, (area of ≈8 hectares)

Other technological considerations

- **CCGT** dual fuel option
- **CHP** plants are mainly biomass-fueled and already subsidized in Estonia.
- **Batteries** (Cf. UK CM capacity additions) are also candidates, but current costs still high and business models (revenue sources) uncertain.
- **DSR** should currently be excluded because of difficulties to identify a standard demand-side resource.
- **Oil shale** fired power plants, such as Auvere plant, recognized environmentally unfit for future.

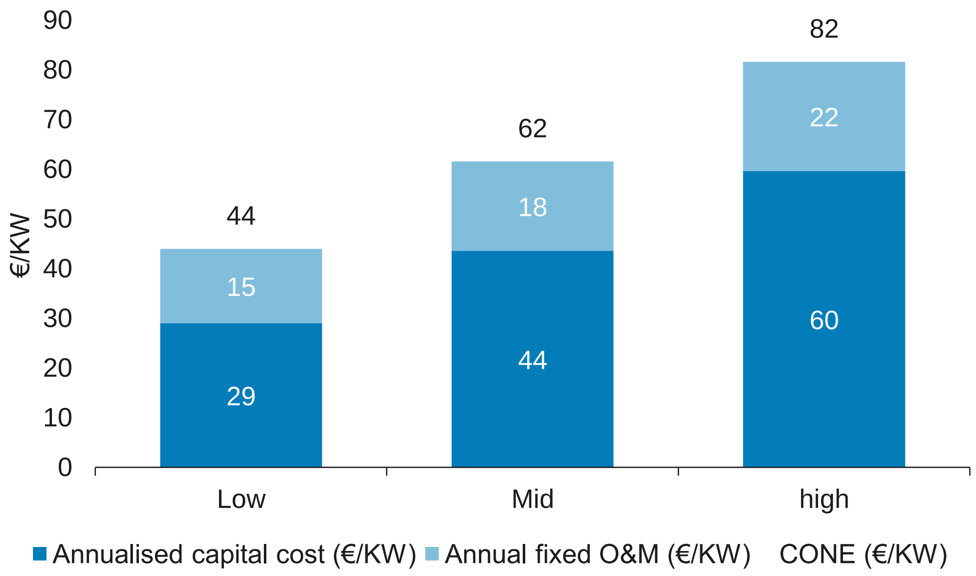
RANGE OF THE EUROPEAN CONE BASED ON OCGT TECHNOLOGY

- Classifying some of the extreme low and high parameters of the European benchmarking exercise as outliers we end up with a representative range for the underlying parameters.
- Based on the narrowed down parameter ranges we estimate a European CONE benchmark for OCGT technology. The mid scenario is equal to **62 €/kW**, and is within the range of **44 - 82 €/kW**.

European CONE parameter ranges

	Low	Mid	High
Investment (€/KW)	400	500	600
WACC	5%	6%	7%
Technical lifetime	22	20	18
Annualised capital cost (€/KW)	29	44	60
Annual fixed O&M (€/KW)	15	18	22
CONE (€/KW)	44	62	82

European CONE benchmark for OCGT



Source: FTI-CL
Notes: The table and figure show the European CONE benchmark for OCGT technology, with monetary units in real 2019 euros.

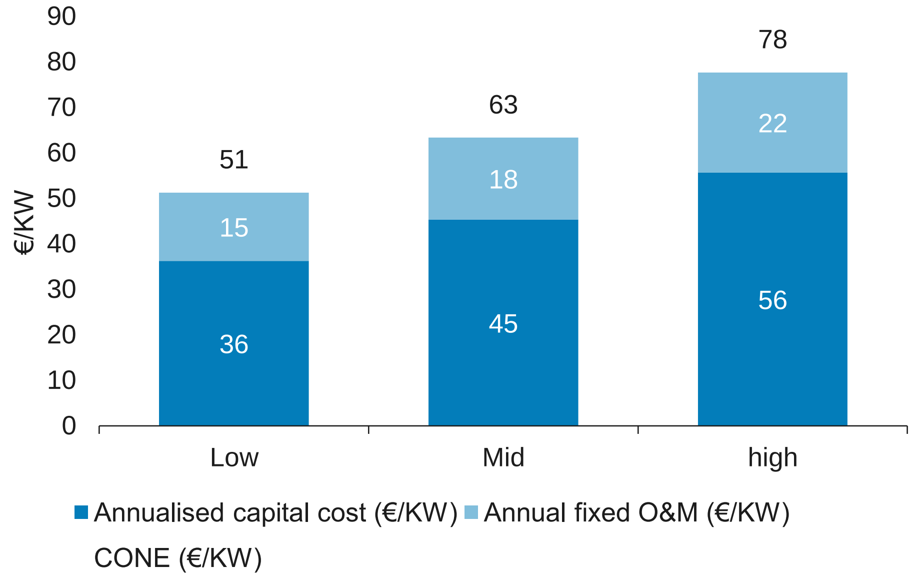
CONE BASED ON ESTONIAN OCGT AND KIISA BENCHMARKS

- Using Estonian-specific benchmarks of OCGT and engines technologies results in a CONE range between **51 – 78 €/kW** for the Estonian OCGT, with the central point of **63 €/kW.**

Parameter ranges behind the Estonian CONE for OCGT based on Kiisa and OCGT bottom-up capital costs

	Low	Mid	High
Investment (€/KW)	500	520	560
WACC	5%	6%	7%
Technical lifetime	22	20	18
Annualised capital cost (€/KW)	36	45	56
Annual fixed O&M (€/KW)	15	18	22
CONE (€/KW)	51	63	78

Estonian CONE for OCGT based on Kiisa and OCGT bottom-up capital costs



Source: FTI-CL
Notes: The table and figure show de-rated CONE ranges for Estonia with monetary values in real 2019 euros.

Reliability Standard for Estonia

WE ESTIMATE THE LOLE TARGET TO BE 9 H/Y, COMPRISED IN A RANGE OF 6 - 12 H/Y DEPENDING ON CONE AND VOLL

The value of LOLE target corresponds to the ratio between the value of CONE and the value of VOLL.

Based on the estimated ranges of the CONE and the VOLL, we estimate the LOLE target to be **9 hours per year** within an overall range between **6 - 12 hours/year** on average. The range of the LOLE target is driven by the following factors:

- A low Value of Lost Load and a high cost of building new generation suggest that additional capacity investment is justified if the number of hours of load curtailment is expected to be high
- Conversely, a high Value of Lost Load and a low cost of building new generation suggest that additional capacity investment is economically justified if the number of hours of load curtailment is expected to be low

Reliability standard for Estonia expressed as LOLE, based on the ranges of the estimated CONE and VOLL

Reliability standard in LOLE (hours/year)		CONE (€/KW-year) low *51*	central *63*	high *78*
VOLL (€/kWh)	*6.5*	7.8	9.7	12.0
	7.3	7.0	**8.6**	10.7
	8.5	6.0	7.4	9.2

Source: FTI-CL
Notes: LOLE reliability standard for Estonia, expressed in yours/year, based on the ratio of cost of new entry (CONE) and value of lost load (VOLL).

A SUPPLEMENTARY RELIABILITY REQUIREMENT BASED ON EENS COULD BE DEVELOPED

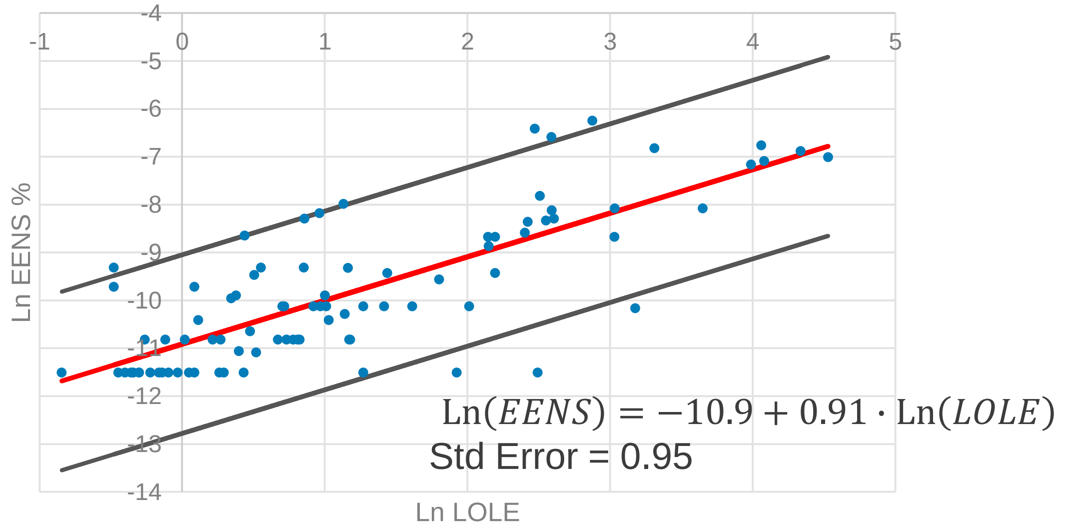
A supplementary reliability requirement based on EENS

- There is no economically justified target for the normalized EENS
- However, to comply with the requirement of CEP to have the Reliability Standard based on both LOLE and EENS, one could consider an additional criteria for the Reliability Standard based on the normalized EENS derived from the empirical relationship between LOLE and EENS.

Secondary reliability standard

- Based on the average of the upper bound of the normalised EENS confidence interval for a given LOLE
- For a LOLE target of 9 hours, such normalised EENS target could be 0.07%, which corresponds to 6GWh

Relationship between LOLE and EENS, MAF 18/19 cross-country



Proposed secondary Reliability Standard based on EENS

LOLE	Normalised EENS target, %	EENS target, GWh
6	**0.046%**	3.9
9	**0.070%**	6.0
12	**0.095%**	8.1

Welfare variation analysis

WELFARE LOSS FROM DEVIATIONS FROM THE RELIABILITY STANDARD

Loss of economic welfare

- As long as Estonian Reliability Standard is derived from the maximization of the social welfare, any deviation from the Reliability Standard should lead to a loss in the social welfare.
- The magnitude of this loss could be an important **factor for policy decisions**.

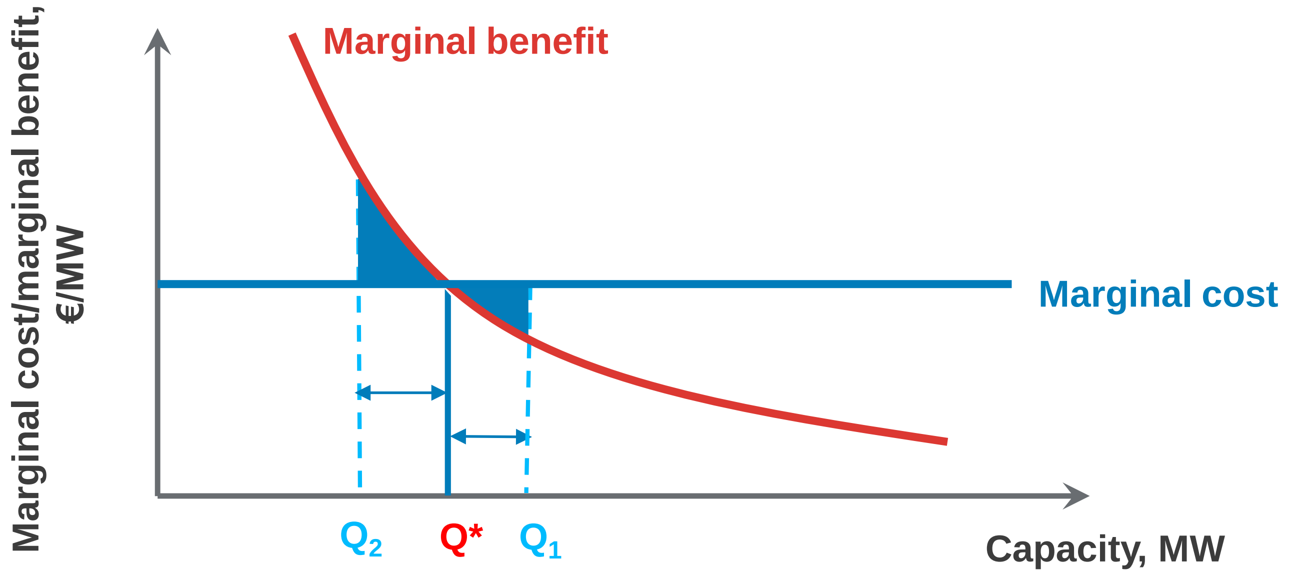
Optimal volume of installed capacity can be found in the intersection of:

- Marginal cost of **additional capacity (CONE)**, and;
- Marginal benefit for customers – value of reduction in **unserved energy (EENS * VOLL)**

Welfare reduction resulting from deviations

- Given by the area between the two curves
- Too much capacity will cost more than the benefit provided to customers
- Too little capacity will result in higher cost of outages to customers than the cost of capacity

Welfare variation resulting from the Reliability Standard deviation



WE USE A PROBABILISTIC APPROACH BASED ON DATA FROM MAF AND ELERING

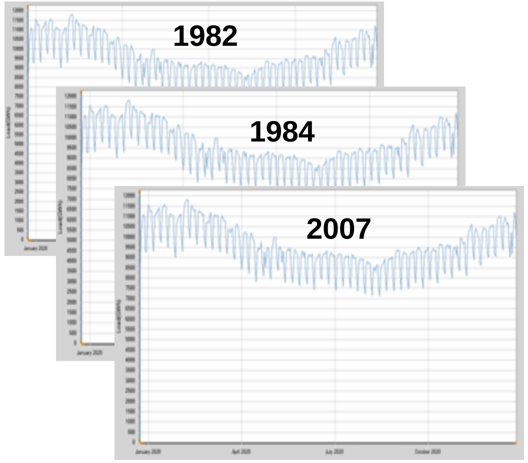
For the quantification of the social welfare resulting from the deviations from the Reliability Standard, we run a probabilistic adequacy analysis consistent with ENTSO-E's Midterm Adequacy Forecast, using:

- Estonian demand and RES generation profiles for three representative climate years identified by ENTSO-E's clustering analysis among 34 samples; and
- The probability of forced outages of the largest interconnectors and power plants in Estonian system.

In particular, for various values of remaining de-rated Estonian capacity, we estimate the expected LOLE based on the variation of RES generation and demand, as well as probability distribution of available capacity of largest interconnectors and power plants in Estonian power system.

Probabilistic adequacy analysis consistent with ENTSO-E's MAF

1) Demand and RES generation



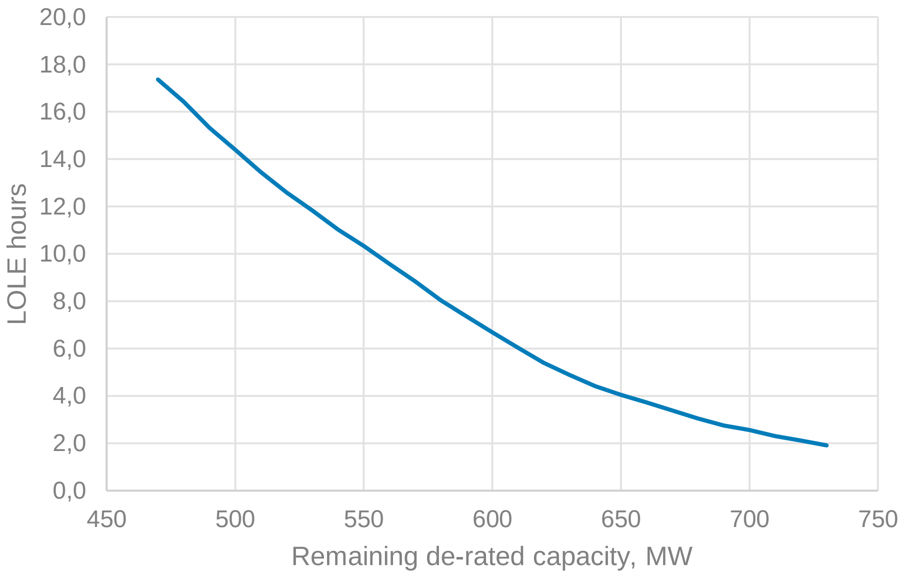
Use of three representative climate years for demand and RES production profiles identified by ENTSO-E's clustering analysis among 34 samples

2) Availability of largest interconnectors and plants

Capacity element	Installed capacity, MW	Outage rates
EstLink 2	650	3%
EstLink 1	350	3%
Auvere TG1	274	5%
Kiisa	250	5%

This creates 16 states of combined availability of four main capacity elements and probabilities assuming no correlation of outages

Probabilistic assessment of expected LOLE as a function of remaining de-rated capacity



Note: Remaining de-rated capacity represents the combined capacity of Estonian power system excluding the four largest interconnectors and plants adjusted for its expected availability during the stress event.

WELFARE SENSITIVITY ANALYSIS BASED ON THE PROBABILISTIC LOLE CURVE

Welfare sensitivity analysis approach

- Evaluate welfare variation as:

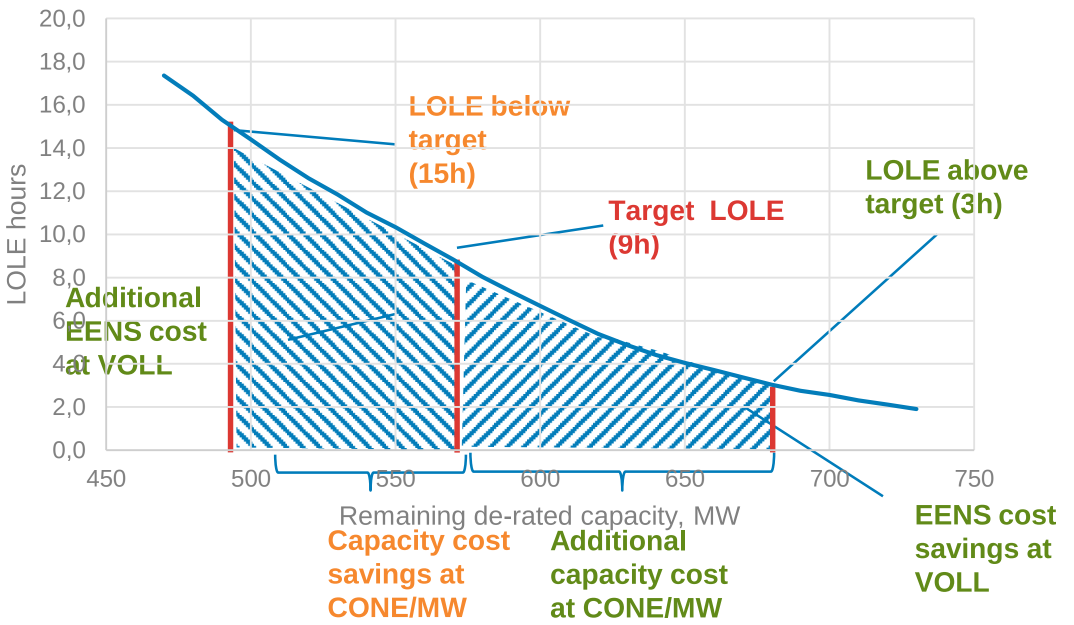
$$\Delta W = \Delta EENS \times VOLL - \Delta Capacity \times CONE$$

- LOLE above target would imply that the cost of additional energy not served outweighs the savings on the cost of additional capacity
- LOLE below target wold imply that the cost of additional capacity outweighs the savings on the cost of energy not served

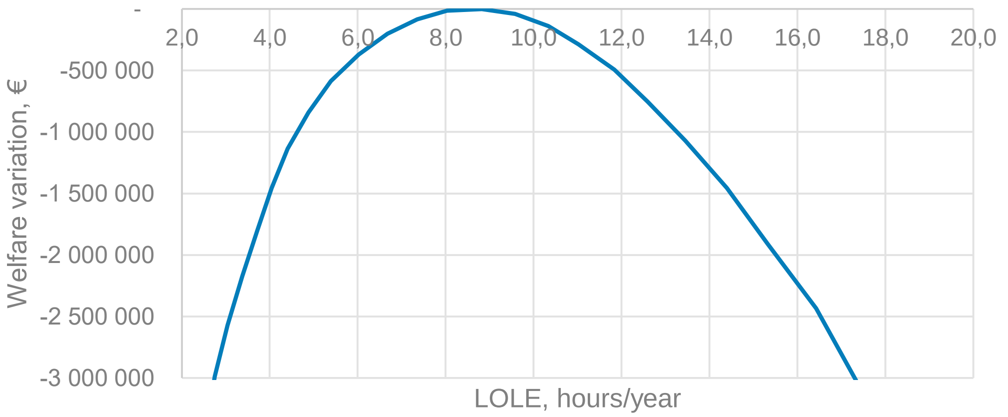
Welfare variation results

- LOLE is sensitive to volumes of capacity, a 110MW additional capacity is sufficient to decrease LOLE from 9 to 3 hours and a deficit of 80MW capacity can increase LOLE from 9 to 15 hours.
- Deviations from the Reliability Standard by 3 hours of LOLE implies a welfare variation within 0.5M€ per year
- Welfare variation reaches 3M€ per year for LOLE of 3 or 17 hour per year

Welfare variation calculation, 2025



Welfare variation, 2025



Conclusion

CONCLUSION

Reliability Standard for Estonia

- The main Reliability Standard for Estonia should be based on LOLE target set according to the economic criteria of welfare maximization at CONE/VOLL
- VOLL for Estonia can be estimated in the range between 6.5€/kWh and 8.5€/kWh with the central point at 7.3€/kWh
- CONE for Estonia an be estimated in the range between 51 and 78 with the central point at 63€/MW
- As a result, LOLE target determining the main Reliability Standard should be in the range between 6 and 12 with the central value of 9 hours.
- A secondary Reliability Standard can be determined based on the statistical relationship between LOLE and EENS in a way to ensure EENS value within the confidence interval for the LOLE target.
- Based on the MAF data for Estonia and across European countries, we derive the EENS target to be in the range between 0.053% and 0.087% with the average of 0.07%.

Welfare variation

- Deviations from the Reliability Standard by 3 hours of LOLE in each direction implies a welfare variation within 0.5M€ per year
- Welfare variation reaches 4M€ per year for LOLE of 3 or 20 hour per year
- This result is mainly driven by the shape of the demand profile and RES production and is robust with respect to the assumptions on outages of main Estonian capacity elements.

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