

# Determination of Reliability Standard Indicator for Portugal

April 2026

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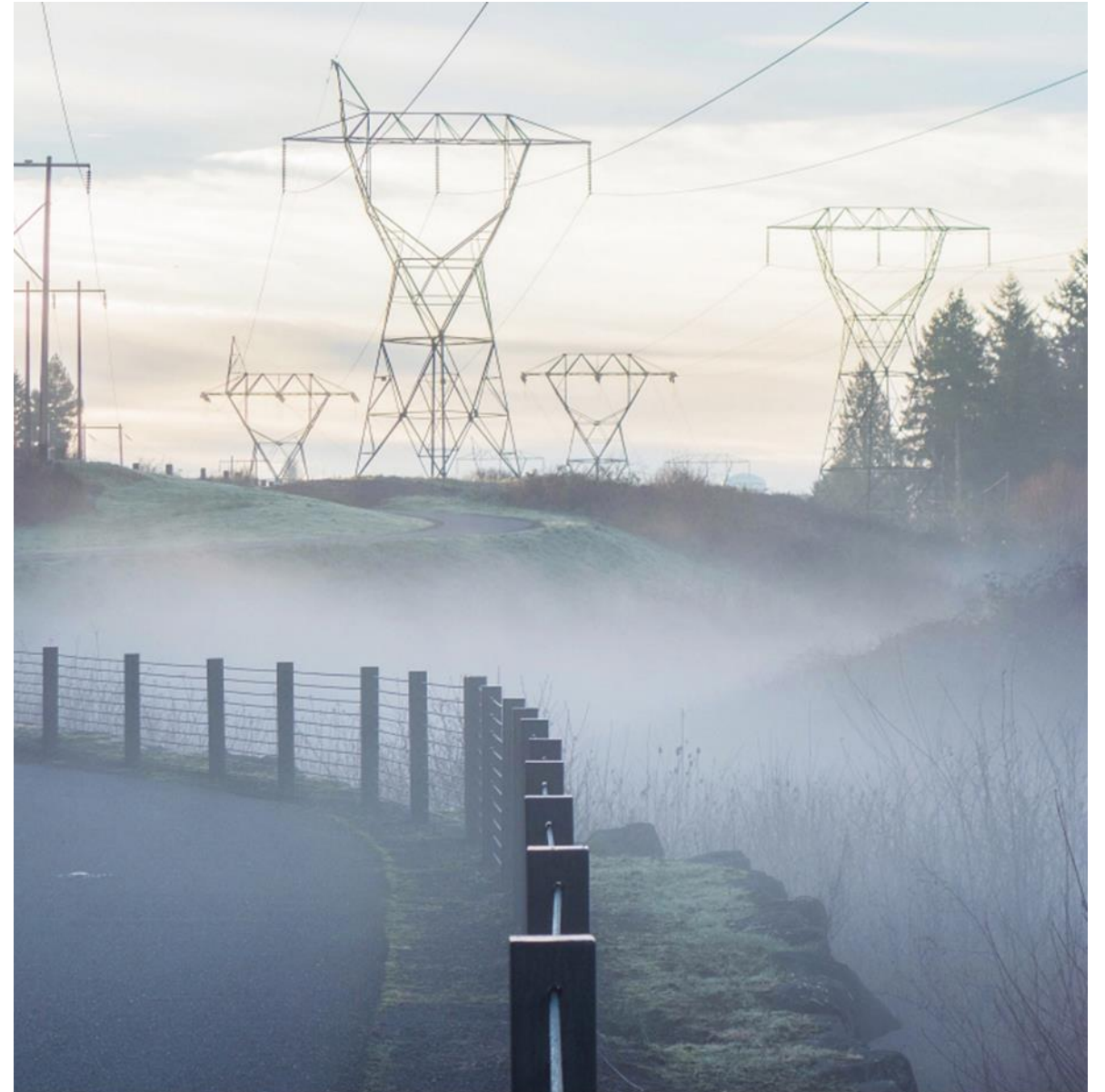
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# Agenda

- Introduction
- CONE/CORP calculation
- VOLL calculation
- RS calculation
- Conclusion and takeaways

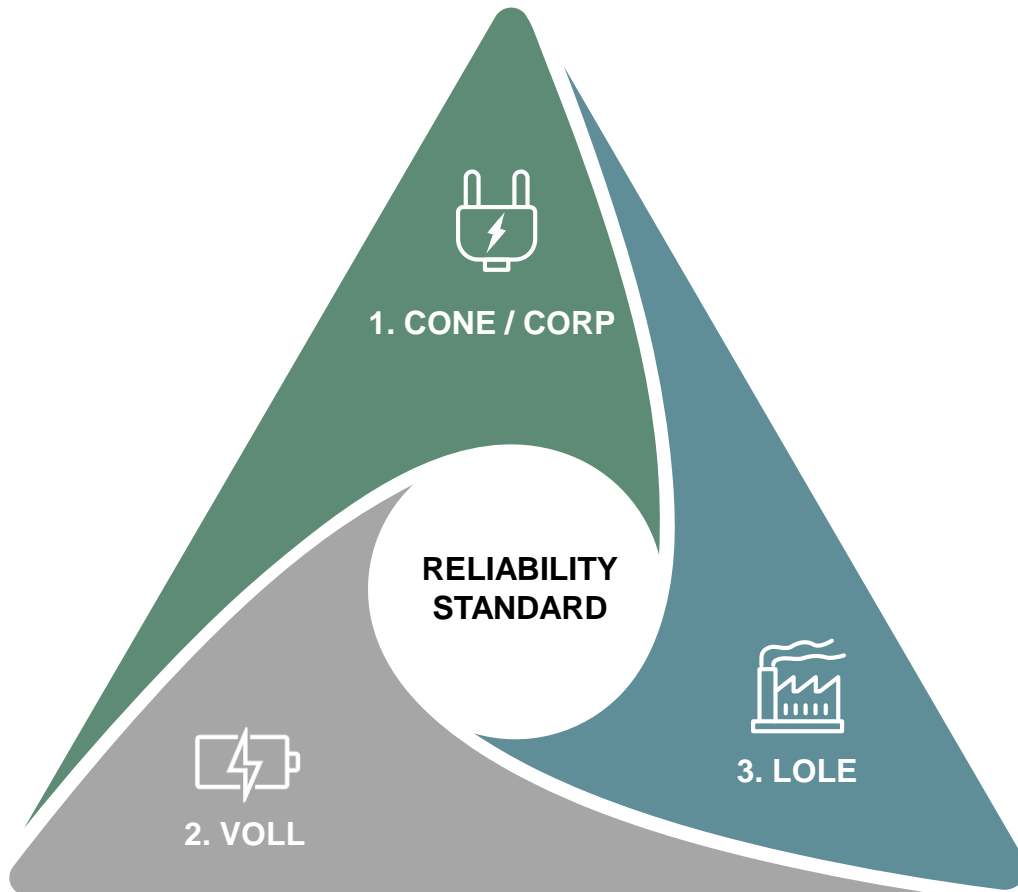


Security of Supply in Europe has been assured through capacity mechanisms



***Ability of an electricity system to guarantee the supply of electricity to customers with a clearly established level of performance, as determined by the member states concerned***

# Reliability Standard balance capacity costs, load shedding costs and acceptable risk



## 1. Cost Of New Entry/Cost Of Renewal or Prolongation (CONE/CORP)

*What is the cost of building new power plants or renewing or prolonging existing ones to increase the security of the system?*

Annualized cost for commissioning and retaining new generation capacity or for keeping an existing generator in operation or prolonging its lifetime.

## 2. Value Of Lost Load (VOLL)

*What is the cost of every MWh of demand not served?*

Maximum monetary value that consumers are willing to pay to avoid an outage.

## 3. Loss Of Load Expectation (LOLE)

*How many hours can demand remain non-served to be more economical than build/renew/prolongate power plants?*

# European Member States apply different approaches to calculate VOLL and CONE, leading to different RS<sup>1</sup>

## Summary of data

Member State	Date	VOLL (€/MWh, nominal money)	CONE/CORP (€/MW-year)	Reference technology for CONE/CORP	RS (h/year)
Belgium	2022	12,832	30,000	DSR	3.00
Cyprus					3.00
Czech Republic	2022	16,003	105,800	OCGT	6.70
Estonia	2020	9,206	72,859	OCGT	8.00
Finland	2022	8,000	17,000	CCGT extension	2.10
France	2022	33,000	60,000	DSR	2.00
Germany & Luxembourg	2021	12,240	57,067	DSR/OCGT	2.77
Greece	2021	6,838	18,735	DSR	3.01
Ireland	2023	17,909	115,990	OCGT	3.00
Italy	2021	20,000	53,000	OCGT	3.00
Netherlands	2022	68,887			4.00
Poland	2023	17,194	30,183	DSR/OCGT	3.00
Slovenia	2022	17,233	21,753	DSR	
Spain	2024	22,879	34,401	CCGT extension	1.50
Sweden	2021	7,870	7,873	DSR	1.00

## Takeaways

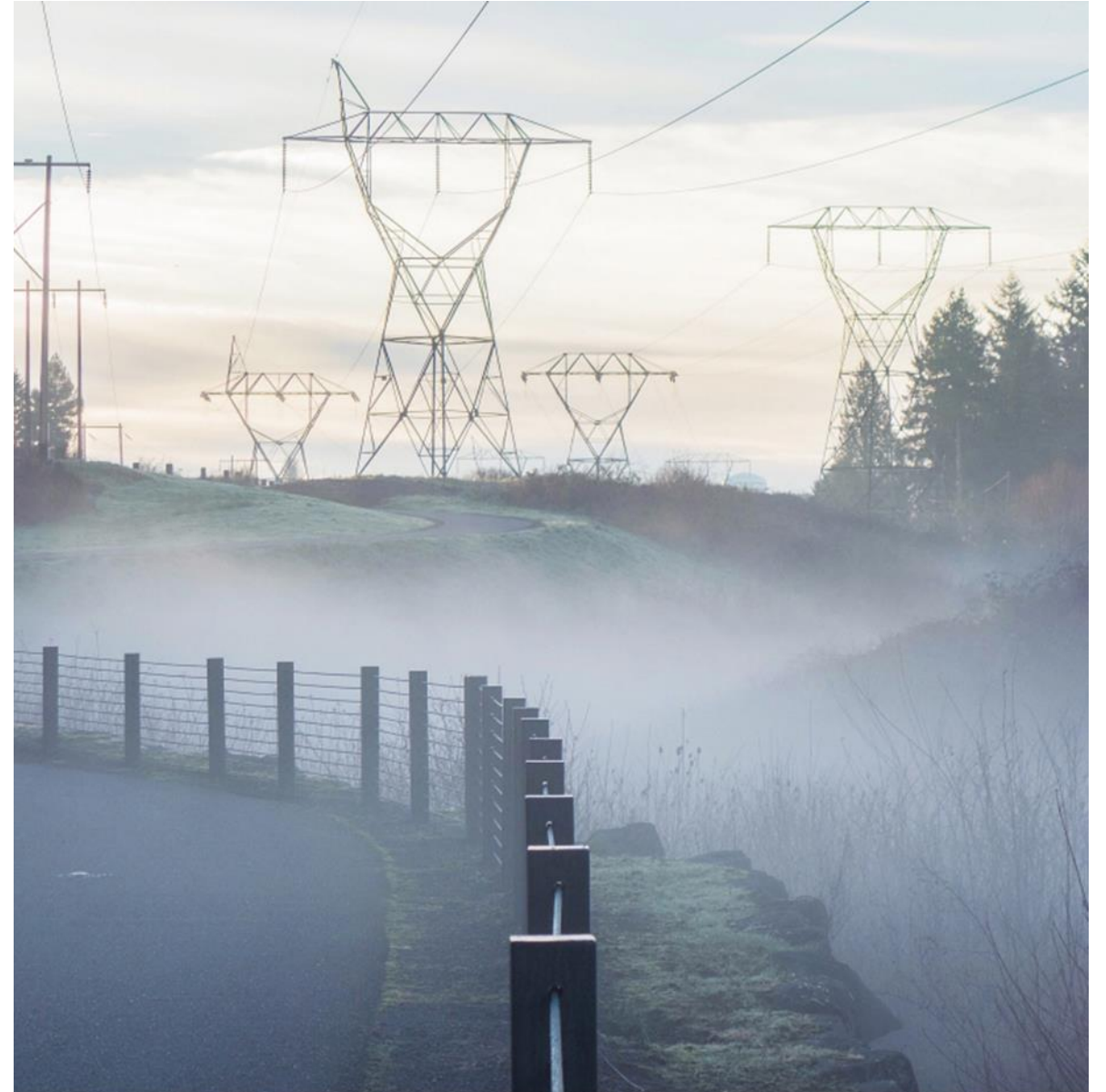
- Wide variation in **VOLL**, from €6,838/MWh in Greece to €68,886/MWh in the Netherlands.
- Not an obvious relationship with economical or weather-related reasons.
- Wide variation in **CONE/CORP**, from €7,873/MW-year in Sweden to €115,990/MW-year in Ireland.
- DSR<sup>2</sup>, OCGT<sup>3</sup> and CCGT<sup>4</sup> extension are the most used technologies.
- **RS** ranging from 1h/year in Sweden to 8h/year in Estonia.
- Median RS of 3h/year.

Notes: 1) Reliability Standard; 2) Demand Side Response; 3) Open Cycle Gas Turbine; and 4) Combined Cycle Gas Turbine.

Sources: information by the Member States (links can be found in the report, <https://www.erse.pt/comunicacao/destaques/erse-vai-realizar-converse-sobre-estudo-e-definicao-da-norma-de-fiabilidade-para-portugal-continental/>).

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- RS calculation
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# Reference technologies and CONE/CORP are defined following ACER guidelines

**01.**

Selection of reference technologies and estimation of their potential

**02.**

Definition of technical characteristics based on reference technologies

**03.**

Estimation of capital and fixed costs for each technology

**04.**

Estimation of the Weighted Average Cost of Capital (WACC)

**05.**

Calculation of CONE/CORP (fixed and variable)

**06.**

Transparency, reliability and objectivity

# Portugal has multiple eligible reference technologies, with CCGT, DSR, batteries and OCGT standing out

## Summary for Portugal

Candidate technology	Standard technology	Potential new entrant	Reference technology	Additional potential (GW) <sup>1</sup>
Battery storage	Yes	Yes	Yes	1.5
Bioenergy/Waste	Yes	Yes	Yes	-
CCGT (new build)	Yes	Yes	Yes	-
CCGT (extension)	Yes	Yes	Yes	3.8
CHP	No	No	No	-
DSR	Yes	Yes	Yes	0.7 <sup>3</sup>
Engines	Yes	No	No	-
Geothermal	No	No	No	-
Hydroelectric power	Yes	Yes	Yes	0.3
OCGT	Yes	Yes	Yes	Non-constrained
Offshore wind	Yes	Yes	Yes	2.0
Onshore wind	Yes	Yes	Yes	4.1
Solar PV	Yes	Yes	Yes	12.4
Tidal	No	No	No	0.2

## Takeaways

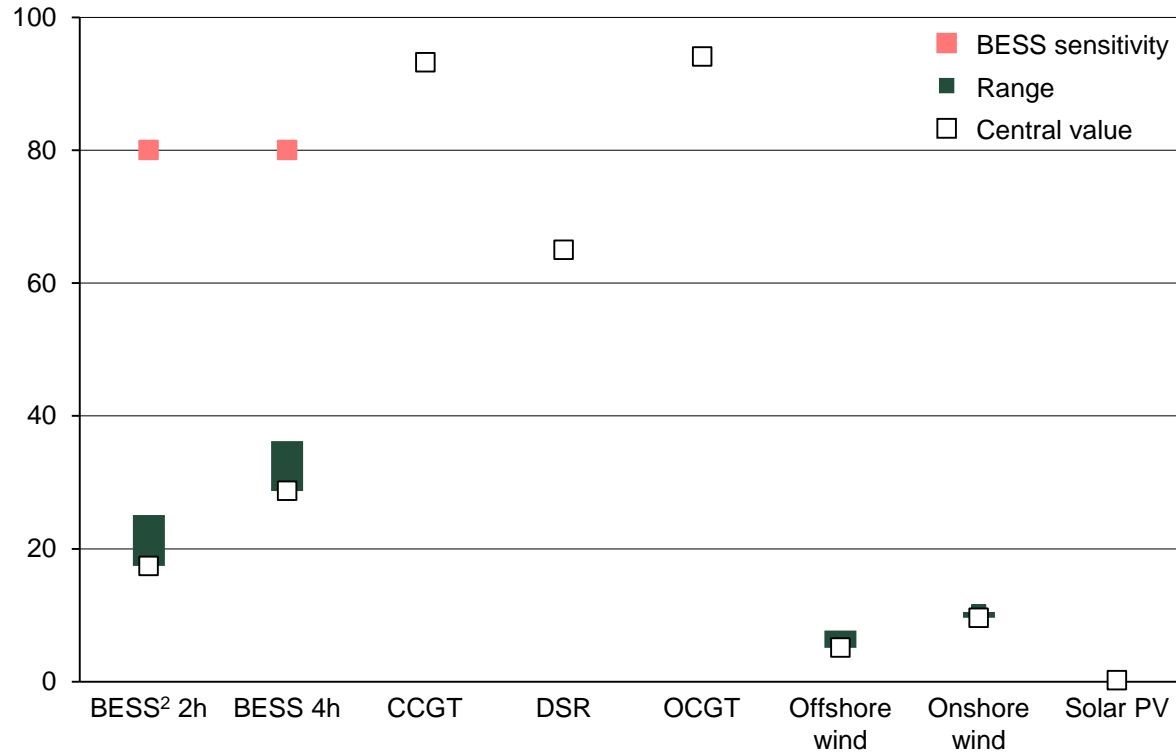
- Definition of **standard technology**:
  - reliable and standardized cost data; and
  - development not constrained by technical limits.
- Definition of **potential new entrants**:
  - capacity developed recently or under development;
  - planned capacity in the NECP<sup>2</sup>; and
  - allowed by local and European regulations.

Notes: 1) to the 2025 reported capacities; 2) National Energy and Climate Plan; and 3) not part of the NECP, but derived by AFRY as part of the analysis.

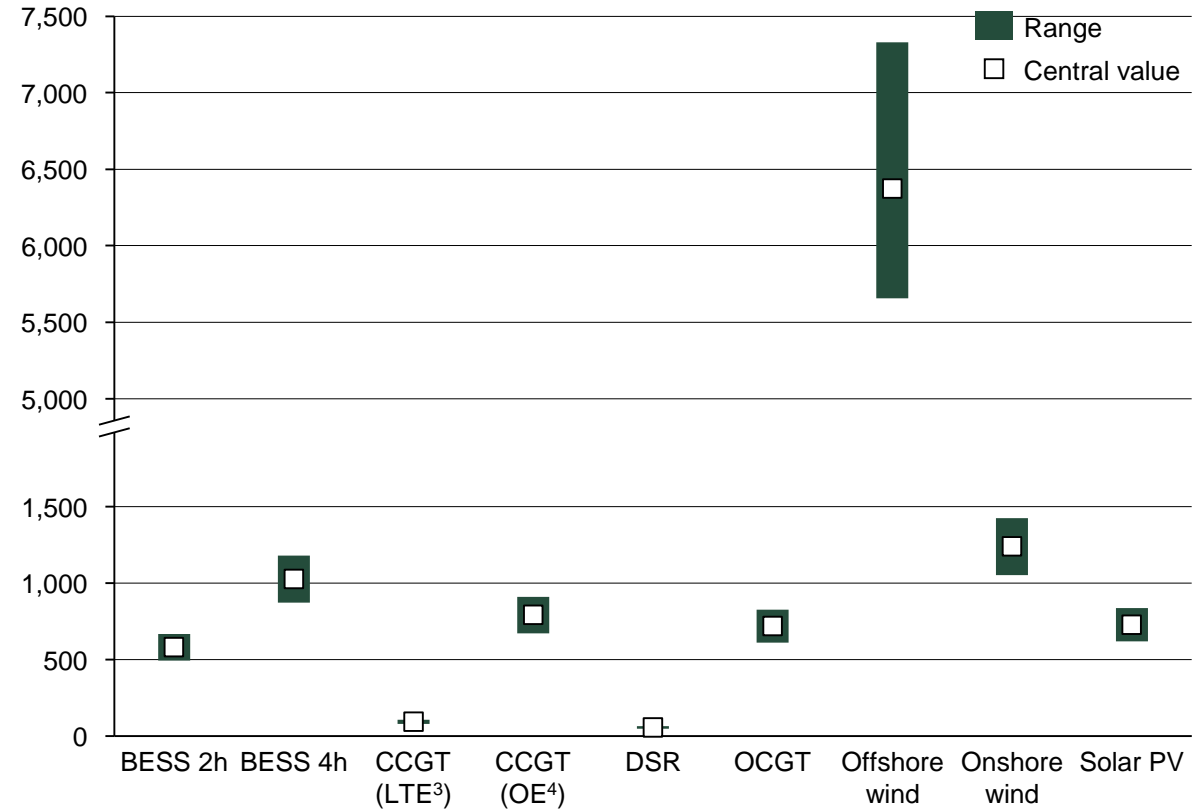
Source: AFRY.

De-rating factors are a key driver of CONE/CORP results across technologies, while CAPEX<sup>1</sup> is the most important cost component

De-rating factors (%)



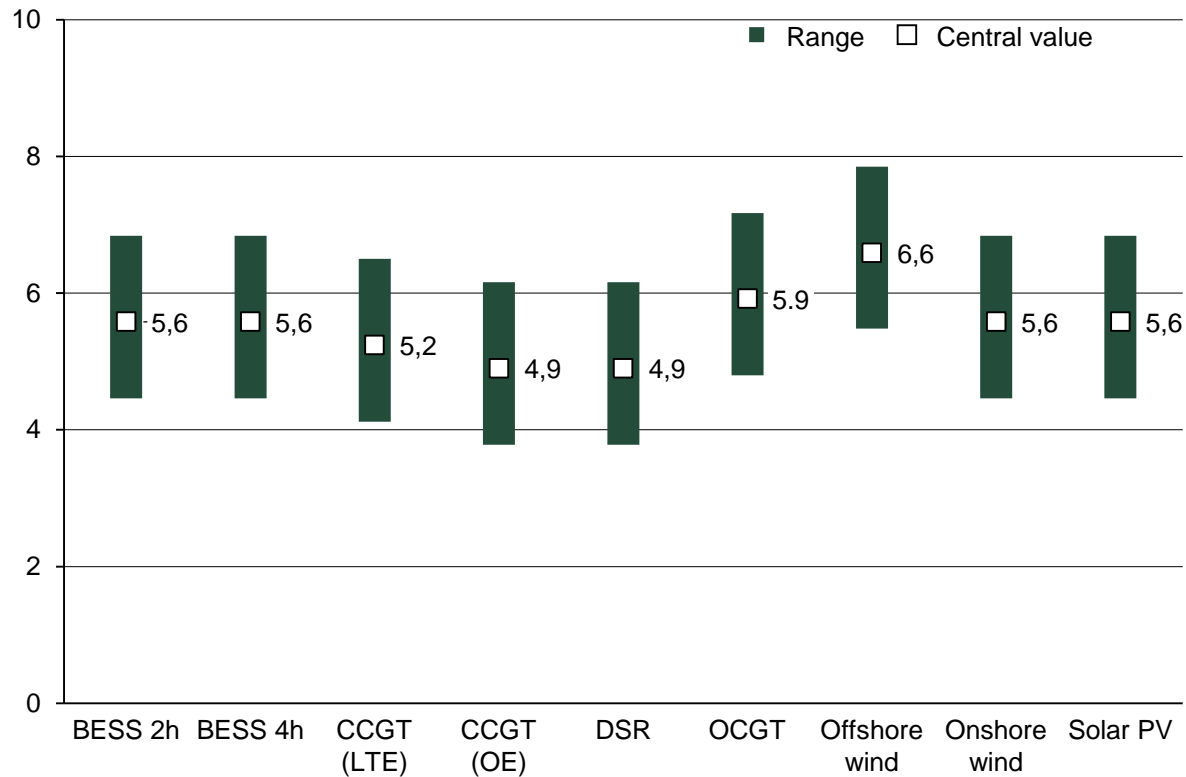
CAPEX (€/kW, real 2025 money)



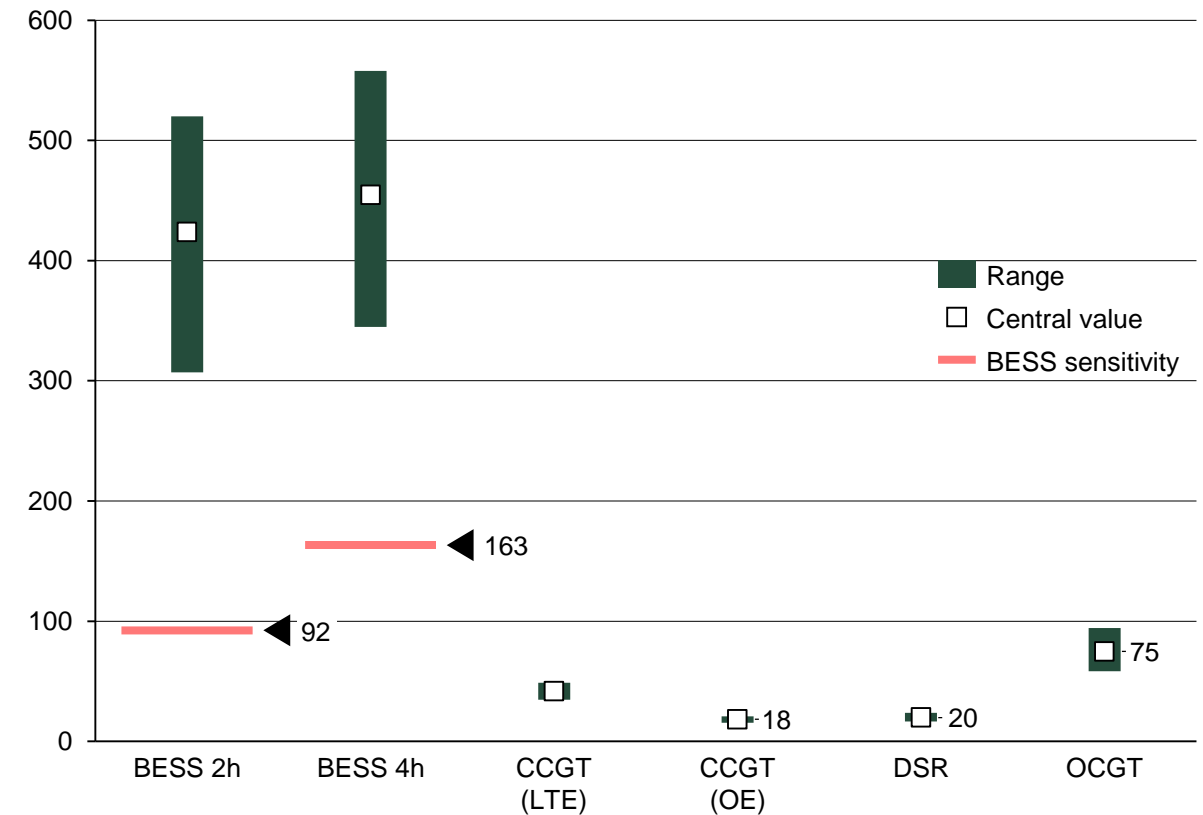
Notes: 1) Capital Expenditure; 2) Battery Energy Storage Systems; 3) Lifetime extension; and 4) OPEX extension.  
Sources: BNEF, ERSE, IEA, IRENA, Gas Turbine World, NREL, UK DESNZ and AFRY.

Differing WACC<sup>1</sup> depending on the technology maturity, alongside the rest of the inputs, lead to CCGT and DSR having the lowest CONE

Pre-tax real WACC (%)



CONE (€/kW-year, real 2025 money)<sup>2</sup>

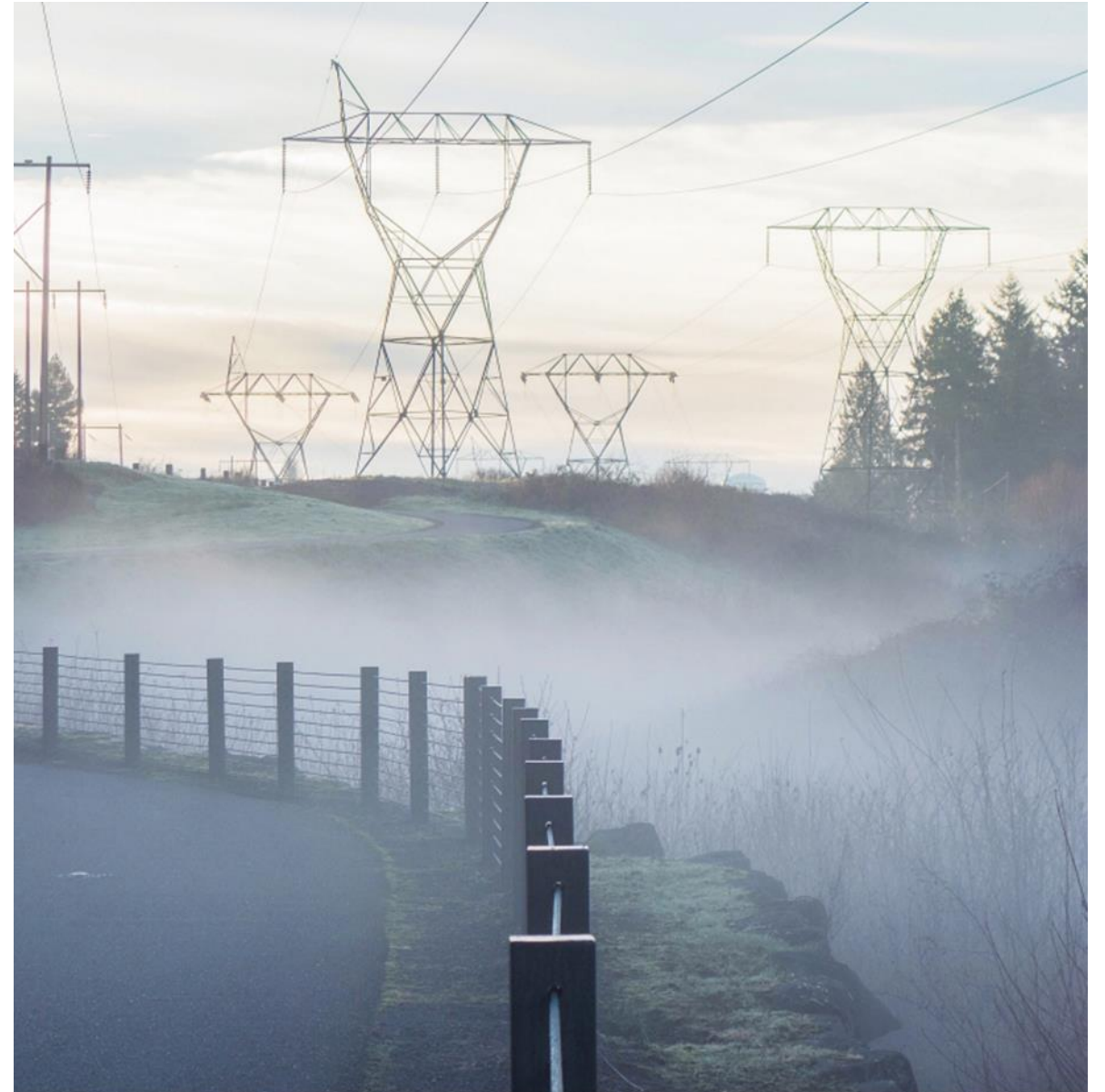


Notes: 1) Weighted Average Capital Cost; and 2) CONE for offshore wind, onshore wind and solar PV not shown in the chart as values are higher than €1,000/kW.

Sources: Damodaran, ECB, ERSE and AFRY.

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# AFRY has followed ACER's guidelines in order to calculate VOLL from surveying Portuguese consumers alongside QMETRICS

**01.**

Customer segmentation:  
households, tertiary, public  
services, industry and transport

**02.**

Definition of VOLL parameters:  
duration, period of occurrence and  
pre-notification of loss of load  
events

**03.**

Statistically representative surveys

**04.**

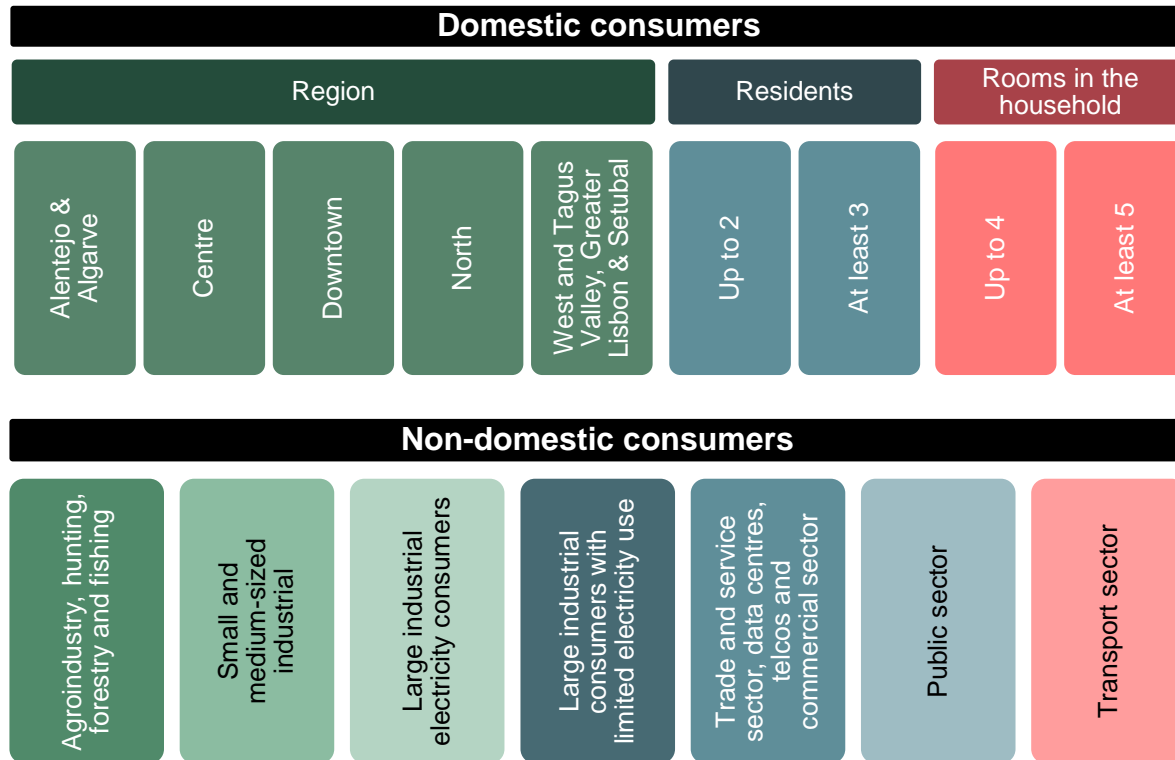
Single VOLL calculation through  
weighting of the different  
consumers

**05.**

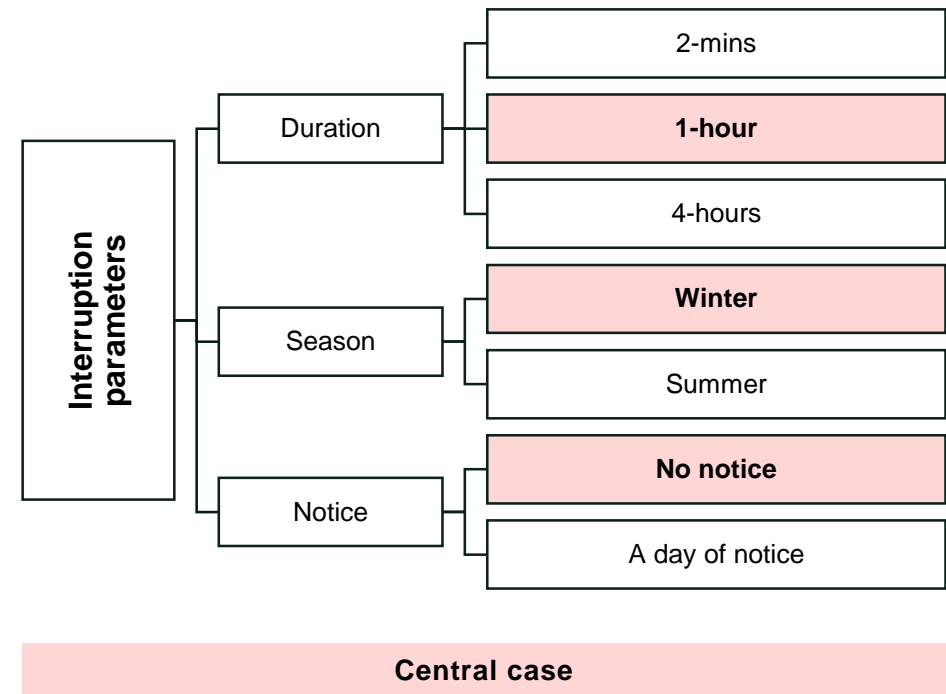
Transparency, reliability and  
objectivity

The consumer segmentation developed allows to group consumers with similar behaviors and their response to electricity interruption scenarios

## Survey segmentation



## Electricity interruption scenarios



# The VOLL calculation is based on data collected in a survey focused on the willingness to pay of consumers to avoid interruptions

## Concepts considered

- The ACER methodology prescribes that **a single VOLL, for the purpose of determining the reliability standard, should be calculated**, reflecting the maximum electricity price that customers are willing to pay to avoid a supply interruption.
  - The **willingness to pay of customers is to be determined based on their responses to a survey**.
  - As per the methodology, the survey is to contain at least:
    - a section for collecting information about the interviewee; and
    - a section describing scenarios of interruption of electricity supply and asking for cost estimates.
- For Portugal, the survey has been designed and performed by QMETRICS:
  - The first section seeks to characterize, segment and collect information on the consumption of the interviewee.
  - The second section has been designed to assess the impact of, and willingness to pay to avoid interruptions.

## Survey division

### Section 1

Explain the context of the survey

Ensure the interviewee is sufficiently knowledgeable to be able to respond in an informed way

Collect the required information regarding the interviewee's consumption

—Collect the necessary information to identify the consumer segment to which

—Identify any consumers that have been price-responsive or protected from load-shedding

### Section 2

Assess impact of interruptions

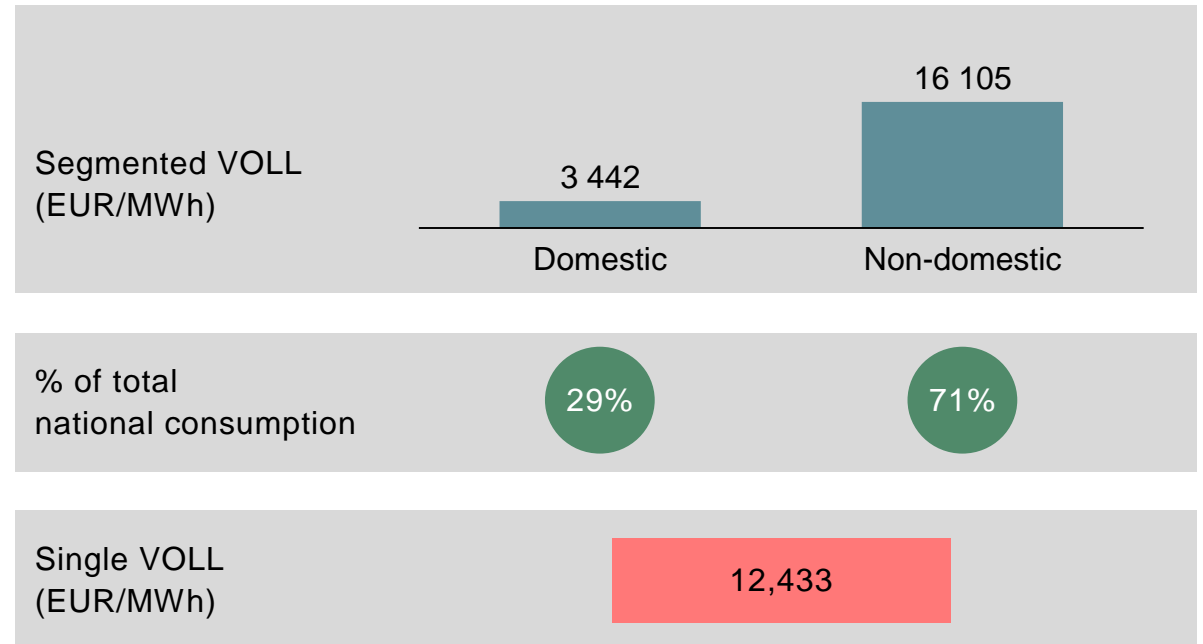
Understand willingness to pay to avoid interruptions to supply in 16 different scenarios

# AFRY has calculated a single VOLL of €12,433/MWh for Portugal, largely driven by the non-domestic segments

## Concepts considered

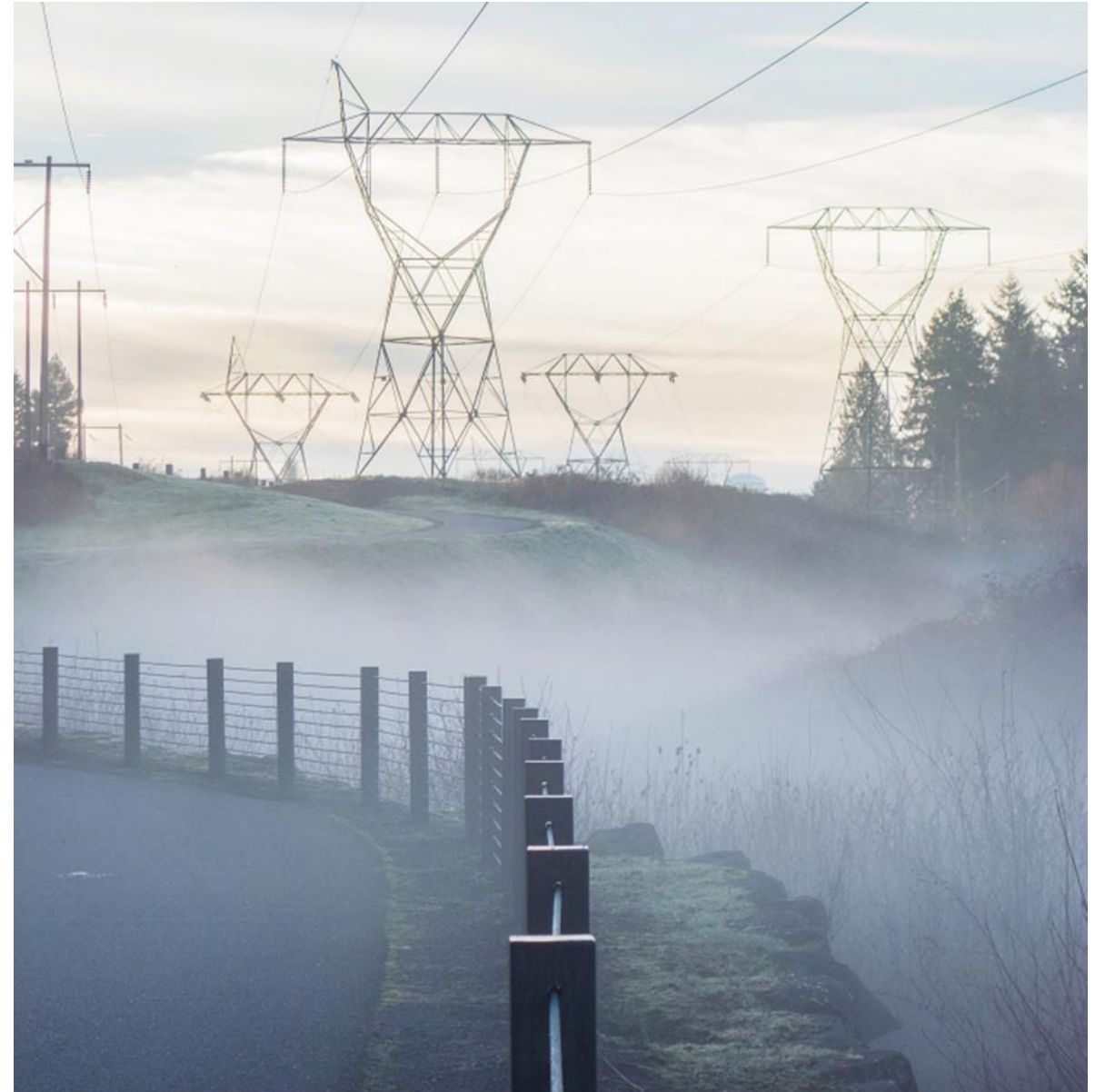
- The ACER methodology requires that the **VOLL for each consumer** sector be evaluated for each **interruption scenario** based on the survey responses.
- The **willingness to pay** responses for each interruption scenario are to be **converted to a VOLL in €/MWh using the electricity consumption of each interviewee, combined with standard load profiles.**
- As a next step, a single VOLL is to be calculated, representing the most likely cost of supply interruptions implemented by the system operators.
  - AFRY has made use of the simplification envisaged in the ACER methodology whereby the sectoral weights may reflect **the average share of load-shedding borne by each consumer sector.**
  - AFRY understands from ERSE that sectors are not prioritized or differentiated for load-shedding purposes, and as a result AFRY assumes that load is shed from the different customer sectors in proportion to their consumption at the time. AFRY has therefore weighted the domestic and non-domestic sectoral VOLL in proportion to the consumption of these sectors.

## VOLL derivation for the Central case



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# Reliability Standard is calculated from LOLE following ACER methodology

**01.**

Calculation of LOLE for every reference technology

**02.**

Verification of the validity of the LOLE

**03.**

Calculation of the RS considering the LOLE and the potential for each technology

# 01.

Calculation of LOLE for every reference technology

The LOLE is determined by the CONE/CORP fixed and the VOLL of the system, as we disregard the CONE/CORP variable

## LOLE equation

$$LOLE_{\text{Reference Technology}} = \frac{CONE/CORP_{\text{Fixed}}}{VOLL - CONE/CORP_{\text{Variable}}}$$



*Our analysis shows that the CONE/CORP variable is generally much lower than the VOLL, and thus can be disregarded*

$$LOLE_{\text{Reference Technology}} = \frac{CONE/CORP_{\text{Fixed}}}{VOLL}$$

## LOLE for the relevant technologies

Technology Candidate	Expected capacity (GW)	LOLE (hours)
<b>BESS (2-hr)</b>	+1.5 GW	34.08
<b>BESS (4-hr)</b>		36.58
<b>Bioenergy/Waste</b>	-	51.35
<b>CCGT (new build)</b>	-	6.97
<b>CCGT (OPEX extension)</b>	2.8 GW	1.46
<b>CCGT (5-year extension)</b>	Potential of +0.99 GW	3.34
<b>DSR (HVAC)</b>	Estimated to be 0.7GW	1.60
<b>Hydroelectric power</b>	-	16.75
<b>OCGT</b>	-	6.01
<b>Offshore Wind</b>	+2.0 GW	1038.08
<b>Onshore Wind</b>	+4.1 GW	96.41
<b>Solar PV</b>	+12.4 GW	2433.87

## AFRY has concluded that the RS in Portugal is 1.46 h/year, set by the extension of the operation of the current CCGT fleet

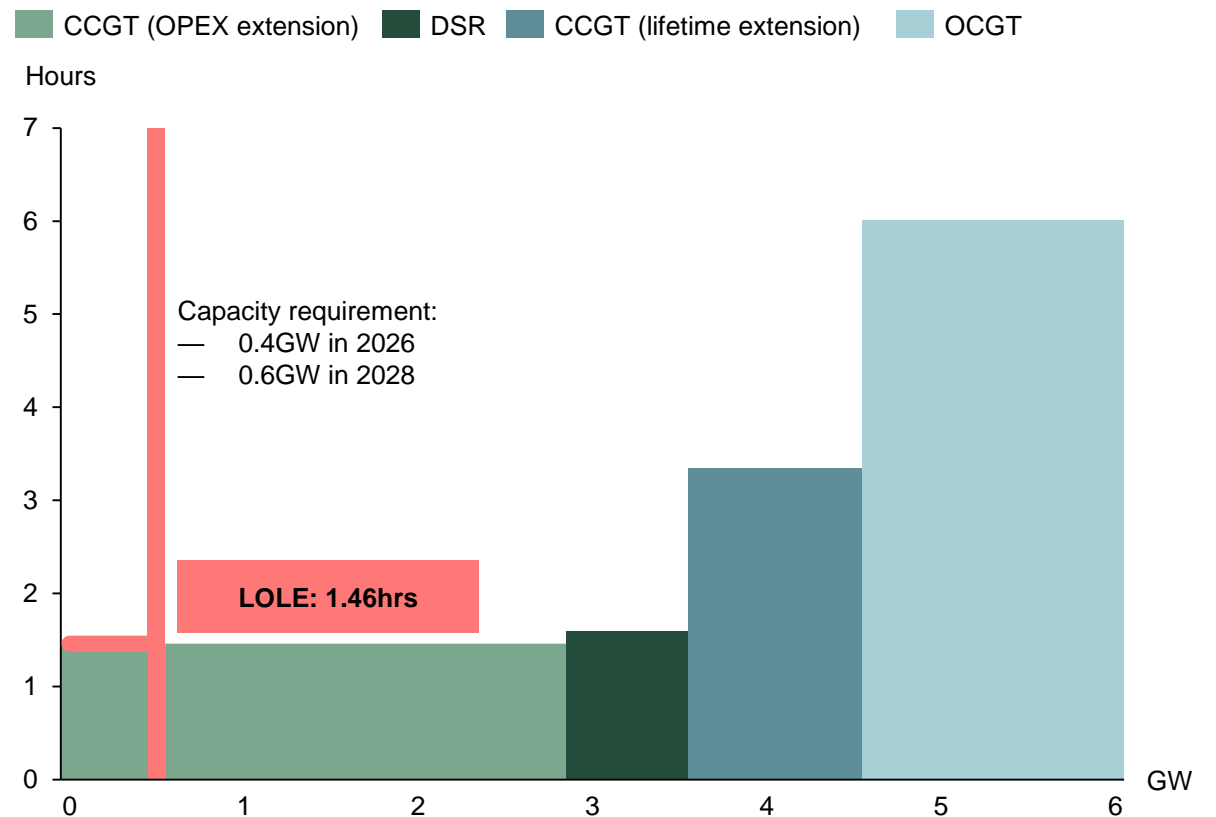
### Methodology

- ACER states that for the **LOLE to be valid**, the conditions expressed below must be met, which **have been confirmed by AFRY**:
  - The marginal reduction of EENS can be expressed in terms of LOLE.
  - Additional capacity resource is required to reduce EENS<sup>1</sup>.
  - EENS is only reduced in the concerned geographical area.
- **Minimum capacity required** to reach the RS according to ACER must be less than (or equal to) the maximum hourly energy not supplied EENS observed in the ERAA or, where applicable, in the regional or national coverage study (i.e., RMSA<sup>2</sup> for Portugal).

Year	LOLE (h)	EENS (MWh)	Minimum capacity required to reach RS (MW)
2026	0.13	9.68	446
2028	0.12	10.36	557
2030	0	0	0
2035	0	0	0

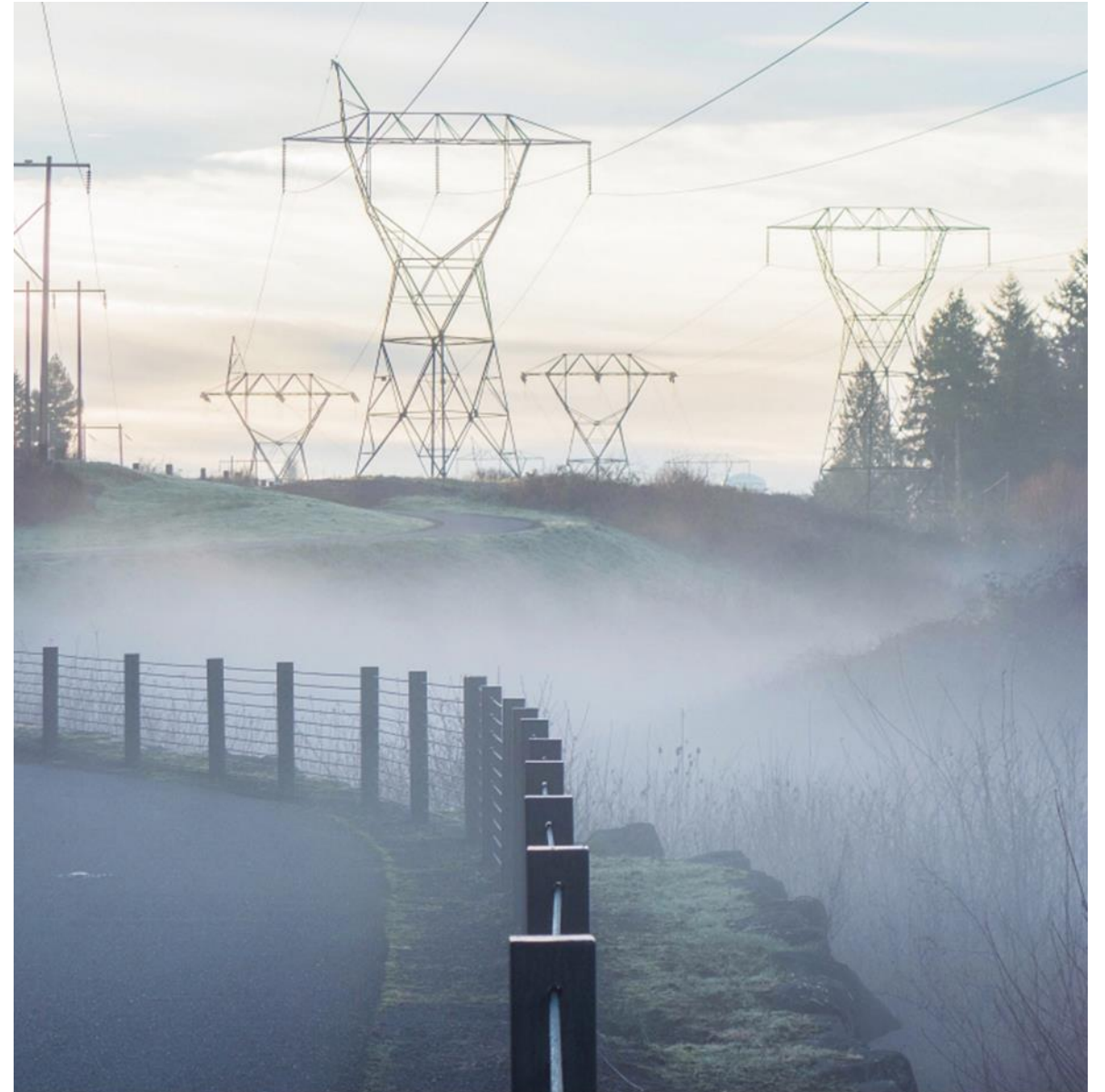
Notes: 1) Expected Energy Not Supplied; and 2) Relatório de Monitorização da Segurança de Abastecimento.  
Sources: ERAA 2024 (<https://www.entsoe.eu/eraa/2024/>) and AFRY.

### RS calculation for 2026 and 2028



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# CCGT extension is the most competitive solution for the system – however, capacity is limited and thus not an appropriate long-term solution

## 01.

Extending the operational lifetime of any existing CCGT – be it through payments to cover the fixed OPEX or a refurbishment – are the first and third most cost-competitive options from the CONE perspective.

Most of the infrastructure is already in place and there is limited or no CAPEX needed.

## 02.

However, there are limitations as to how much capacity can be extended and for how long.

Thus, using this might not be an appropriate long-term solution.

## 03.

OCGTs are the mainstream technology with the most competitive CONE with potential for development of new build capacity.

AFRY considers this technology to be the most well-grounded technology to be used in the determination of the long-term RS.

The ACER methodology does not include the market revenues of the potential reference technologies – AFRY has followed the approach yet considers there is room for improvements

## 04.

The CONE defined through ACER's methodology corresponds to what in literature can be regarded as the gross CONE, as no adjustment is made due to potential revenues from the energy market.

This means the analysis cannot capture the actual missing money of the technology (which would correspond to the net CONE), but rather the full cost of new entry for the technology (as previously mentioned, gross CONE).

## 05.

AFRY has followed the methodology as set by ACER, though considers that improvements can be applied to better capture the competitiveness of technologies.

## 06.

Interconnections are also excluded as a reference technology for CONE/CORP.

Currently, none of the MS consider interconnection as part of their analysis, although four of them (i.e., Belgium, France, Italy and Poland) are open to their participation in the capacity mechanism, according to ACER.

Future reviews might need to evaluate whether including interconnectors could be a viable alternative.



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