Mid-term Adequacy Forecast @ a glance

2016 Edition

European Network of Transmission System Operators for Electricity

entsoe

CONTENTS

01

INTRODUCTION TO THE MAF

02

OUR MAIN FINDINGS

This Mid-term Adequacy Forecast (MAF) 2016 @ a Glance is a very short presentation of the findings of this new mid-term assessment of Pan-European adequacy. The MAF replaces ENTSO-E's System Outlook and Adequacy Forecast or SOAF. The move from SOAF to MAF is due to a significant change in the methodology used for the assessment. The MAF 2016 is one of ENTSO-E's mandates under EU legislation. It will be out for public consultation during the summer 2016. A final report after stakeholder feedback has been taken into account will be issued during the autumn.

01

INTRODUCTION TO THE MAF

1. INTRODUCTION TO MAF

WHAT IS THE "MAF" ?

The Mid-term Adequacy Forecast (MAF) is a Pan-European assessment of the risks to security of supply and the need for flexibility over the next decade. The methodology used by ENTSO-E takes into account the transformation of the power system with increasing variable generation from renewable energy sources.

The recommendations of the Electricity Coordination Group (ECG) in 2013 invited ENTSO-E to update their adequacy methodology and assessments to better account for the risks to security of supply and the need for flexibility as the Pan-European power system moves towards higher levels of variable renewable energy sources (RES). These improved assessments should also help highlighting the contribution of electricity interconnectors to national adequacy at times of potential scarcity.

The methodology used in ENTSO-E's adequacy reports has evolved in response to the ECG recommendations and stakeholder consultation during 2014. These resulted in the so-called "ENTSO-E Adequacy Target Methodology" and implementation roadmaps[1].

The ECG[2], stated that adequacy assessments are more useful when focussed on the mid-term horizon (up to 10 years ahead). These can be used to assess potential load shedding risks and send signals to both market players and decision-makers of the need for the generation fleet to evolve. Adequacy assessments are less informative beyond this period due to the increasing levels of uncertainty around the future energy systems. The mid-term adequacy forecast (MAF) fulfils the role of providing a Pan-European adequacy assessment for the next ten years.

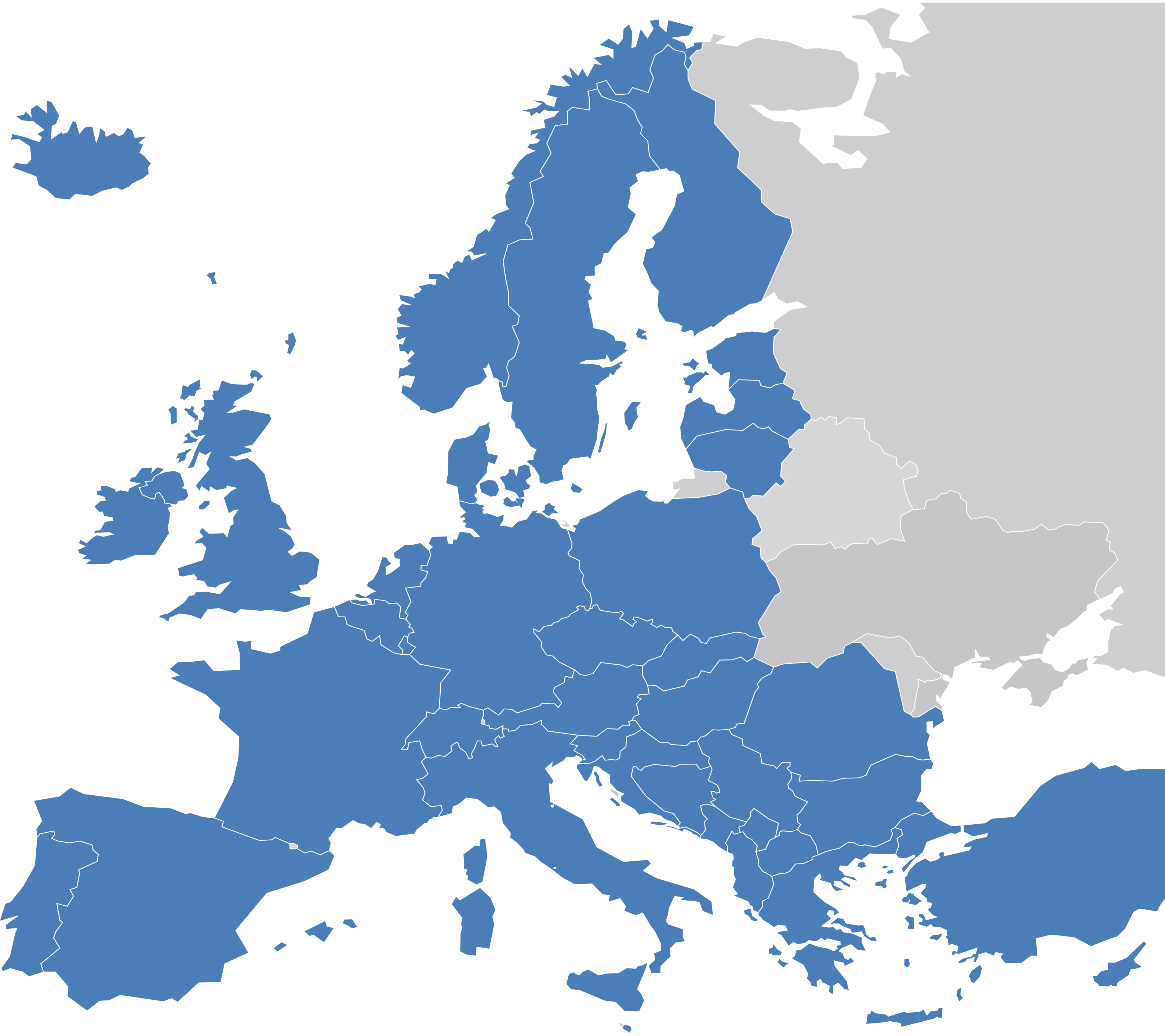
METHODOLOGY: HAS ENTSO-E DEVELOPED SOMETHING NEW?

The MAF presents the first Pan-European assessment of generation adequacy using market-based probabilistic modelling techniques. Additionally the MAF's results have been benchmarked using four different calculation software tools.

The MAF presents the first Pan-European probabilistic assessment of adequacy. While market-based probabilistic modelling approaches have already been adopted in some national generation adequacy studies and the Pentlateral Energy Forum (PLEF) regional adequacy assessment[3], this is the first time such studies have been conducted at the Pan-European level. This represents a significant analytical achievement. Moreover, this has involved extensive collaborative effort of representatives from TSOs covering the whole Pan-European area under the coordination of ENTSO-E.

[1] https://www.entsoe.eu/about-entso-e/system-development/system-adequacy-and-market-modeling/adequacy-methodology/Pages/default.aspx
[2] Report of the European Electricity Coordination Group on The Need and Importance of Generation Adequacy Assessments in the European Union, Ref. Ares(2013)3382105 - 30/10/2013
[3] http://www.benelux.int/files/4914/2554/1545/Penta_generation_adequacy_assessment_REPORT.pdf

PAN-EUROPEAN PERIMETER CONSIDERED



The MAF 2016 represents a number of achievements worth highlighting. These include:

1. The study involves the whole Pan-European perimeter including Turkey
2. The results have been benchmarked by calibration of four different analytical tools, which also account for the regional differences in power systems across Europe. This increases the consistency and robustness of the complex analytical results presented in the report, and helps to improve the links between the MAF and regional/national adequacy studies.
3. Also noteworthy are a number of important technical developments that meant it was possible to adapt the analysis to the specific requirements of different regions within Europe.

These include:

- an advanced temperature-sensitive load model
- harmonised probabilistic hydrological analysis with data sets for extended dry and wet hydro conditions
- forced outage rates (FOR) for thermal units as well as on HVDC links

WHAT IS THE SCOPE OF THE MAF AND HOW DOES IT LINK WITH REGIONAL / NATIONAL ADEQUACY ASSESSMENTS?

The MAF aims to identify and assess the risks to generation adequacy on a Pan-European level. It should be regarded as providing a boundary regarding data and assumptions for further studies at regional level and national level.

The main scope of this report is to identify and assess the risks to generation adequacy on a Pan-European level. The report is updated annually so that the assessments are carried out using the best available information (for example: demand projections, available generation capacity, commissioning and decommissioning of assets and infrastructure elements, etc). Moreover, an annual assessment is designed to provide consistent Pan-European boundaries that help defining a framework for further studies at regional level and national level.

Regional and national studies allow greater focus on sensitivities and potential solutions that are most relevant to the areas concerned. Pan-European assessments help to ensure the necessary consistency between the different regional/national assessments and any of the proposed solutions within those.

The application of consistent methodologies at national, regional and European level is necessary to allow a realistic assessment of available cross-border support considering many different scenarios. The methodology should therefore be common between these three levels, but taking into account national specificities. However, the decision to implement measures to ensure security of supply at national level remains directly linked to the responsibility for security of supply.

ENTSO-E has developed consistent bottom-up scenarios for the future European power systems in 2020[6] and 2025. The scenarios are designed to assess adequacy based on key metrics such as energy not-served (ENS) and loss of load expectation (LOLE), and considering the role of interconnection as well as cross-border exchanges. The analysis has been carried out on data that has been collected from all TSOs within the Pan-European perimeter based on principles set out by ENTSO-E.

All tools used in these study are used by TSOs for national, regional and Pan-European studies. All tools have been tested to ensure that they are able to match the basic methodology requirements of performing probabilistic market modelling adequacy assessments. TSOs have expertise in using these tools and are able to capture the important features of their national or regional perimeter for the Pan-European simulations. Comparison of results between tools ensures quality and robustness of the inputs as well as of the results. Also this exercise ensures the consistent link between Pan-European studies performed here and possible subsequent regional or national studies by TSO.

[6] The 2020 scenario considered here is fully consistent with the Expected Progress 2020 scenario of TYNDP2016.

Pan-European studies will contribute to the debate and trigger discussions and actions if one/several countries present adequacy issues. Those countries could build on the analysis here performed and use the same methodology to check and consider solutions both locally and/or within a regionally coordinated framework. Regional and national studies will also benefit from increased quality of data in neighbouring countries from the Pan-European framework developed here. The Pan-European , regional and national levels can complement each other by use of a common methodology, data and assumptions.

WHAT ARE THE LESSONS LEARNT?

1) Use of sophisticated modelling tools requires a huge effort but provides a significant added value to increase the quality and robustness of the results

2) The simulations are computationally demanding and require a permanent group of TSO modelling experts to improve the methodology, align assumptions, achieve robust results and spread knowledge at the same time.

3) Coordination is needed between ENTSO-E's Pan-European assessment and national studies

Each step towards increasing the level of details of the data and representation used in the models significantly increases the complexity of the mathematical problem to be solved. The complex probabilistic simulations performed in MAF 2016 for the whole Pan-European perimeter have resulted in computationally demanding simulations. The modelling tools' computational capabilities have been tested and pushed by TSOs in this study. For instance each simulation run of the base case took over several days for all tools available. This should be taken into account in order to understand the effort needed for calibrating the models.

There is an opportunity to work closer with the TSO's to better understand their timelines for producing national adequacy reports, and where possible, seek greater harmonisation with the timelines of the annual MAF publication. This will help improve the consistency of data, analysis and key messages between the national reports and the MAF, which will help ensure stakeholders realise the benefits from all studies.

WHAT ARE THE LIMITATIONS OF THE CURRENT METHODOLOGY? WHAT ARE THE NEXT STEPS?

A market model always presents a simplified representation of the real behaviour of the power system. The results obtained in this report should always be understood under the following assumptions and limitations of the current implementation of ENTSO-E methodology.

- Use of 14 years (2000-2013) climatic years within ENTSO-E Pan-European Climate Database .
- Market models use actual Bidding-Zones (BZ) configurations and the modelling of each market zones consider them as congestion free zones or 'copper plate'.
- No explicit modelling of intraday trading or balancing market is performed. In order to make this simplification more sensible for adequacy studies, sensitivity runs including and excluding the contribution of operational reserves have been considered.
- Transmission capacities between BZs are considered as constant across the year. Power exchange limits do vary in reality and are dependent on maintenance schedules and unexpected unavailability of system's elements. In order to make this simplification more sensible for adequacy studies, conservative assumptions have been considered. Also sensitivity runs assuming 'forced outages' for selected HVDCs have been considered.
- No explicit modelling of DSM/DSR has been performed in this report. Potential for load reduction capabilities has been however collected from TSOs. Although for some TSOs these figures do present a view on, market based demand side response meaning that if prices are getting high, some consumers will

not consume, in general the figures collected present last resort emergency capabilities available to TSOs, rather than estimates for a future market for DSM. Due to the heterogeneity of the available data, these figures have been used only in relation to the discussion of the results.

- No flow-based market coupling has been modelled in this report. The exchanges obtained in this report should therefore be understood as 'commercial flows' and not as 'physical flows'. In addition, the use of simultaneous importable/exportable capacities aims to prevent the modelling of non-realistic commercial flows.
- The scenarios analysed in MAF 2016 for 2020 and 2025 are based on a best estimate of the evolution of the generation mix (thermal and renewable park) and transmission capacity as well as demand forecast of each country. These scenarios are referred as Scenario B "Best Estimate/Expected Progress". For 2020 this scenario is common to the TYNDP2016 2020 scenario. Within the principles set out by ENTSO-E for a common and consistent data collection, all TSOs have provided data considering to their best knowledge the evolution of their generation mix, in some cases including "economic viability" of the scenarios provided. No further sensitivity has been performed regarding "economic viability" of the data provided by TSOs and instead the focus has been on the identification of Pan-EU adequacy risks for those scenarios.

There is a need for continued development of both the modelling tools and the underlying data assumptions within ENTSO-E MAF reports. Further developments are envisaged for future MAF reports:

- Extension of the Pan-European Climatic Database (PECD) to 35 climatic years,
- Revision of cross-border interconnector assumptions to account for seasonality and operational constrains,
- Revision of thermal portfolio categories and data details and assumptions therein.
- A European overview on anticipated decommissioning of power plants is needed to improve the quality of the data and accuracy of the adequacy assessments performed by ENTSO-E. ENTSO-E welcomes interaction with relevant stakeholders to further improve the availability of data regarding decommissioning/mothballing of plans and considerations of so-called "system-relevant" assets.
- Modelling of demand-side management and demand-side response
- Use of flow-based market methods.

HOW SHOULD THE RESULTS BE INTERPRETED?

It must be noted that the conclusions in this report are cannot be seperated from the hypotheses described and can only be read in reference to these. The hypotheses were gathered by the TSOs according to their best knowledge at the time of the data collection and validated by ENTSO-E's relevant committees.

ENTSO-E and the participating TSOs have followed industry practice in the collection and analysis of data available. While all reasonable care has been taken in the preparation of this data, ENTSO- E and the TSOs are not responsible for any loss that may be attributed to the use of this information. Prior to the taking of business decisions, interested parties are advised to seek separate and independent opinion in relation to the matters covered by this report and should not rely solely upon data and information contained herein. Information in this document does not amount to a recommendation in respect of any possible investment. This document does not intend to contain all the

02

OUR MAIN FINDINGS - OVERVIEW OF RESULTS (PRESENTATION WITH FEEDBACK FROM TSOs)

information that a prospective investor or market participant may need.
ENTSO-E emphasises that the association and the TSOs involved in this study are not responsible in case the hypotheses taken in this report or the estimations based on these hypotheses are not realised in the future.

HOW TO UNDERSTAND THE PROBABILISTIC RESULTS OF THE MAF?

Probabilistic simulations are needed to account for all possible combinations of uncertainties that the power system will face in the future. It is also important that these combinations account not only for the average conditions of the system but, even more importantly, also for the most extreme conditions which typically will push the power system to a stressed situation (e.g. situations of scarcity). With increased shares of variable renewable energy sources in the system, the most critical situations may occur in future at times other than peaks in demand.

Also seasonality/climate factors should be properly considered in combination, for example: low temperatures leading to high demand in winter (or high temperatures leading to high demand in summer) combined with dry years, low precipitation, leading to scarcity of water in hydro reservoir, etc.

Probabilistic methods use climate databases to assess the variability of RES (renewable energy sources) production as well as the seasonality of demand and hydro production and thermal production availability.
A simulation of a given hour of the interconnected Pan-European power system is performed by combining Load × RES × Hydro × Thermal × Cross border capacity factors.
The example below shows two possibilities:

- The first hour presents an example of a potentially critical situation
- The last hour is a rather moderate situation in which no problems are expected

For each future scenario of installed capacities of the Pan-European power system (2020 and 2025 scenarios) a systematic combination of all uncertainties is performed to setup the hourly simulations of the interconnected Pan-European system. This is the so called *Monte-Carlo* method. In this chapter we present the main results of these simulations.

For each scenario 2020 or 2025 and each simulation run, a total number of hourly simulations [8760 hours – variables calculated] is performed by further considering combinations of: 14 climatic Wind – PV - Temperature year situations × between 3 and 6 hydrological yearly situation depending on the region × 200 – 300 situations for random outages sample of thermal units and HVDC links.

HOUR	LOAD	RES	HYDRO	THERMAL	CROSS BORDER CAPACITY	
Scenario 2020 Hour 1	Low /High Temp High Demand (Winter/Summer)	Low Wind Low PV	Dry conditions Low hydro production	Low availability of Thermal generation	Low cross border capacity	⚠
...	...	...	...	...	...	
Scenario 2025 Hour 8760	Moderate Temp Moderate Demand	High Wind High PV	Wet conditions	Normal availability of Thermal generation	Normal cross border capacity	✓

For each hour of this simulations a value of ENS is calculated. This value can be either:

ENS = 0 (no adequacy problem)

or

ENS ≠ 0 (adequacy problem found)

The number of times a given value of ENS is found is counted and stored. This number divided by the total number of simulations, gives you an idea of the 'probability' of occurrence of this value of ENS.
Bookkeeping of the number of counts of ENS allows us to construct the so-called Probability Distribution (PD) function.

The PD function for ENS typically looks like the one illustrated on p. 13. Usually, most of the time the records found that ENS = 0, i.e. that the system is adequate. However due to the large number of possibilities considered, different sets of hours with different values of ENS are found. A small number of hours report a very large value of ENS, when the system might face significant scarcity situations.

HOW TO EXTRACT THE MAIN MESSAGES FROM THE WEALTH OF DATA FROM THE PROBABILITY DISTRIBUTION?

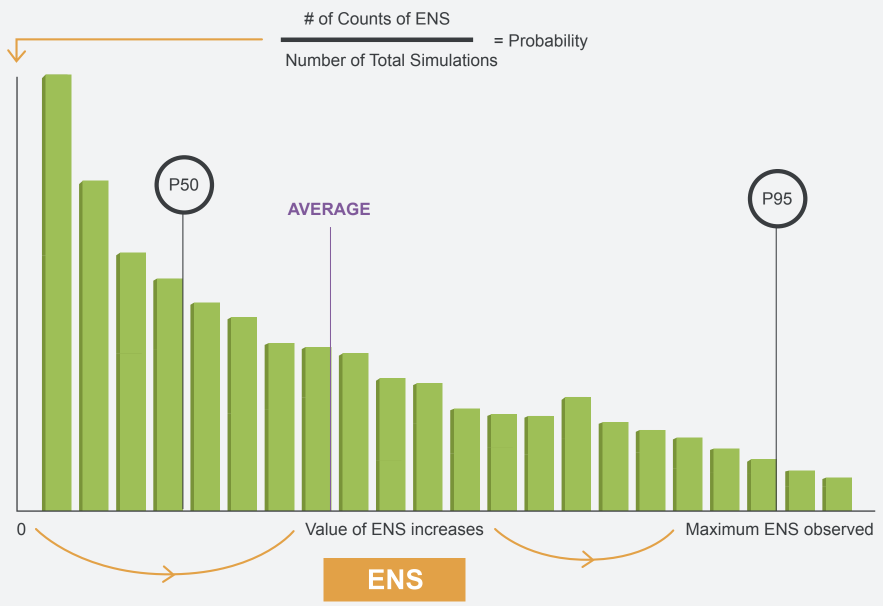
This is done by computation of the so-called Median (P50), Average and "1 in 20 years' (P95).
Average (mean): This is the average value of ENS found among all the situations
ENS = sum of all ENS / sum of all Simulations.

Median (P50): This is the value of ENS for which there are equal number of simulations reporting ENS >P50 than ENS< P50 (ENS > (or <) P50%, 50% of the times). The area covered by the PD on the left and on the right hand side of the P50 value are therefore equal. Note that if the distribution would be symmetric, P50% and Average would coincide. The fact that P50 < ENS, indicates that the PD is not symmetric and the presence of so-called long tails of ENS, large values of ENS which can be found, with very low but finite probability.

Extreme situation "1-in-20 years" (P95): This is the value of ENS for which 95% of the values found are lower than P95 (ENS < P95% - 95% of the times). Only 5% of values found are higher than this value. P95 gives a measure of high values of ENS which are likely to occur with very low but still some probability of occurrence. P95 gives a measure of the 'low probability – high impact, (worst case '1-in-20 years') situation observed'.

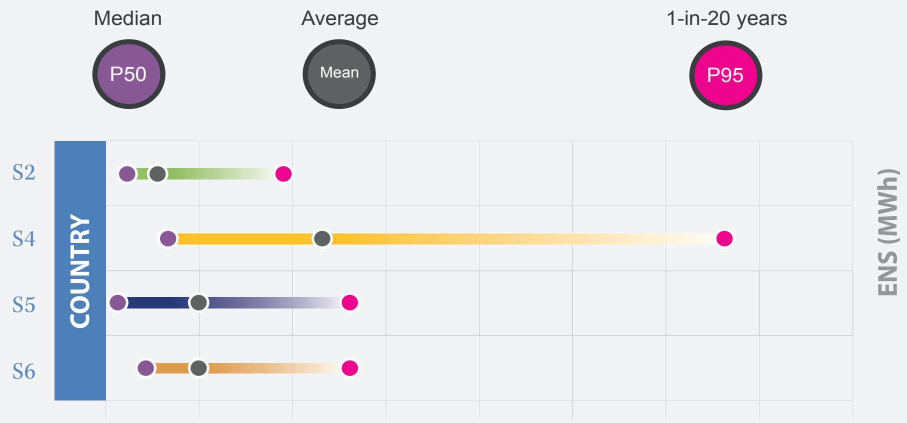
These 3 values (P50, Average and P95) are indicated in the probability distribution example shown on the graph.

PROBABILITY DISTRIBUTION EXAMPLE



For each simulation, the P50, average and P95 values are reported for the countries which indicate adequacy problems.

Furthermore, since the simulations have been performed with several tools, referred as simulator or S2, S4, S5, S6, the results of the different tools are also presented, next to each other.



OVERVIEW ADEQUACY SITUATION FOR 2020 AND 2025

- *LOLE < 1 hour* — green
- *LOLE > 1 hour but under conservative modelling assumptions* — blue
- *LOLE > 1 hour* — red

COUNTRY	2020			2025
	BASE CASE	SENSITIVITY CASE I	SENSITIVITY CASE II	BASE CASE
AL	green	green	green	green
AT	green	green	green	green
BA	green	green	green	green
BE	green	green	green	red
BG	red	green	green	green
CH	green	green	green	blue
CZ	green	green	green	green
DE	green	green	green	blue
DK	green	green	green	red
EE	green	green	green	green
ES	green	green	green	green
FI	red	green	red	red
FR	red	red	red	red
GB	red	red	red	red
GR	red	green	green	green
HR	green	green	green	green
HU	green	green	green	green
IE	red	green	green	red
IT	red	green	green	red
LT	green	green	green	green
LU	green	green	green	red
LV	green	green	green	green
ME	green	green	green	green
MK	green	green	green	green
NI	red	green	green	red
NL	green	green	green	red
NO	green	green	green	blue
PL	blue	blue	blue	blue
PT	green	green	green	green
RO	green	green	green	green
RS	green	green	green	green
SE	green	green	green	blue
SI	green	green	green	green
SK	green	green	green	green
CY	red	green	green	green
TR	green	green	green	green

SUMMARY ADEQUACY INDICATORS (ENS AND LOLE) FOR 2020

The table below provides an overview of the values for Energy Non-Served (ENS) and Lost of Load expectation (LOLE) found for several countries within the Pan-European perimeter and within the different simulations performed for year 2020 and 2025. The full MAF reports will include in its Appendix, countries' comments on the results obtained in the MAF 2016, with each country's own assessment of adequacy level, its national adequacy standards and the measures taken to maintain these in case of problems.

Only countries with average LOLE > 1 hour in the Base Case are included in the table below:

		Base Case				Sensitivity (1)				Sensitivity (2)			
Country	**Sim.**	**ENS (MWh) Average**	**LOLE (h) Average**	**ENS (MWh) Average (all)**	**LOLE (h) Average (all)**	**ENS (MWh) Average**	**LOLE (h) Average**	**ENS (MWh) Average (all)**	**LOLE Average (all)**	**ENS (MWh) Average**	**LOLE (h) Average**	**ENS (MWh) Average (all)**	**LOLEAverage (all tools)**
GB	S2	14247	7.8	12090	**7.6**	7834	4.5	7082	**4.4**	--	--	8501	**5.4**
	S4	5440	3.6			4877	3.2			5534	3.6		
	S5	13612	7.5			7877	4.4			9927	5.6		
	S6	15061	11.5			7742	5.4			10043	7.0		
FR	S2	3332	2.3	3418	**2.6**	303	0.3	1059	**0.8**	--	--	1176	0.8
	S4	4439	2.9			3251	2.2			3293	2.2		
	S5	912	0.7			552	0.4			85	0.1		
	S6	4991	4.7			130	0.1			150	0.2		
FI	S2	1014	3.3	1905	**5.7**	1	0.0	16	0.1	--	--	260	**1.0**
	S4	23	0.1			8	0.1			369	1.3		
	S5	2044	5.9			29	0.1			153	0.6		
	S6	4540	13.6			27	0.1			258	0.9		
IT	S2	94	0.5	951	**2.9**	0	0.0	69	0.2	--	--	94	0.3
	S4	198	0.8			165	0.6			170	0.6		
	S5	589	3.3			2	0.0			2	0.0		
	S6	2922	7.0			109	0.2			111	0.2		
PL	S2	86	0.2	456	**1.1**	0	0.0	101	**0.3**	--	--	182	**0.5**
	S4	0	0.0			0	0.0			0	0.0		
	S5	479	0.7			0	0.0			33	0.1		
	S6	1260	3.4			404	1.1			514	1.3		
GR	S2	448	1.5	386	**1.6**	0	0.0	1	0.0	--	--	2	0.0
	S4	0	0.0			0	0.0			0	0.0		
	S5	16	0.1			0	0.0			0	0.0		
	S6	1081	4.7			5	0.0			5	0.0		
BG	S2	0	0.0	364	**1.4**	0	0.0	26	0.1	--	--	34	0.1
	S4	4	0.0			1	0.0			1	0.0		
	S5	545	1.9			53	0.2			51	0.2		
	S6	905	3.5			49	0.2			50	0.2		
NI	S2	179	1.1	128	**1.2**	17	0.1	13	0.2	--	--	17	0.3
	S4	17	0.6			11	0.4			15	0.5		
	S5	194	1.0			10	0.1			11	0.1		
	S6	123	2.3			15	0.2			25	0.4		
IE	S2	224	1.0	175	**1.1**	22	0.1	25	0.2	--	--	41	0.3
	S4	55	0.6			37	0.4			48	0.5		
	S5	244	1.1			25	0.1			33	0.1		
	S6	179	1.7			15	0.2			43	0.3		
CY	S2	1	0.1	46	**4.2**	0	0.0	7	**4.2**	--	--	9	**5.6**
	S4	0	0.0			0	0.0			0	0.0		
	S5	96	2.2			0	0.0			0	0.0		
	S6	86	14.5			27	16.8			27	16.9		

2020 Base Case

MAIN MESSAGES

These results provide an outlook of the main adequacy problems for a 2020 scenario assuming operational reserves are not contributing to adequacy (e.g. operational reserves constrains on top of day-ahead market considerations)

The following countries present average LOLE > 1 h: BG, CY, FI, FR, GB, GR, IE, IT, NI, PL.

The table provides an overview of the average ENS and LOLE found after the probabilistic simulations.

Results for GB: The simulations show average LOLE and ENS values of ~ 7 – 8 h and ~ 15 GWh, respectively.

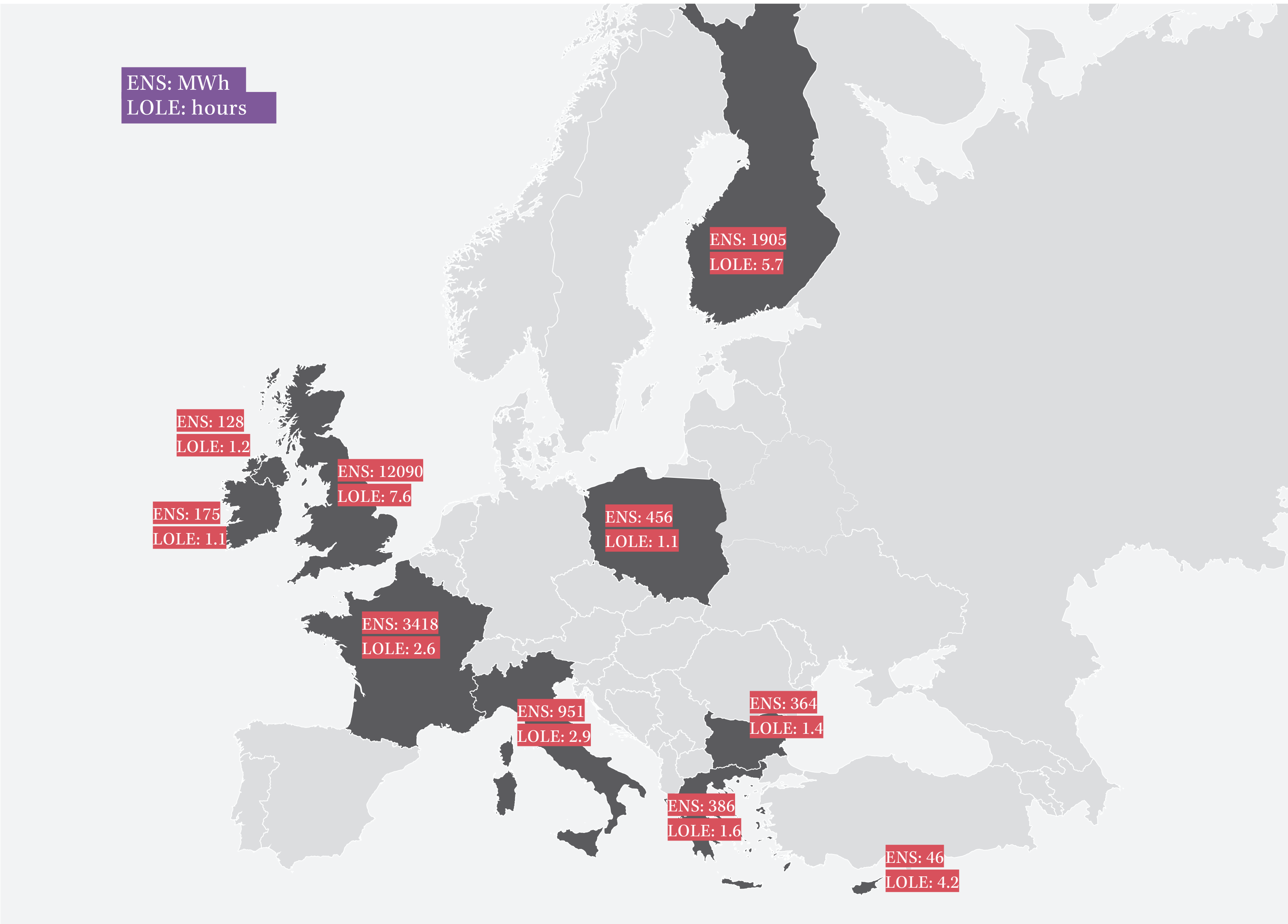
Great Britain has a national reliability standard of 3 hours/year LOLE, which the MAF 2016 results exceed.

The results for GB are based on data from National Grid's Gone Green scenario published in the 2015 Future Energy Scenarios (FES). The Gone Green scenario assumes a number of new interconnectors will be available from 2020 onwards. The modelling assumptions in the MAF have adopted a conservative approach to new interconnector capacity. This is useful to assess the potential impact of interconnector projects being delayed across Europe. As a result, most of the new interconnectors assumed to be available in National Grid's scenario have been excluded from this analysis. This capacity has not been replaced with anything else and so the modelling assumptions have created a shortfall of capacity. This has led to higher LOLE / ENS values for GB.

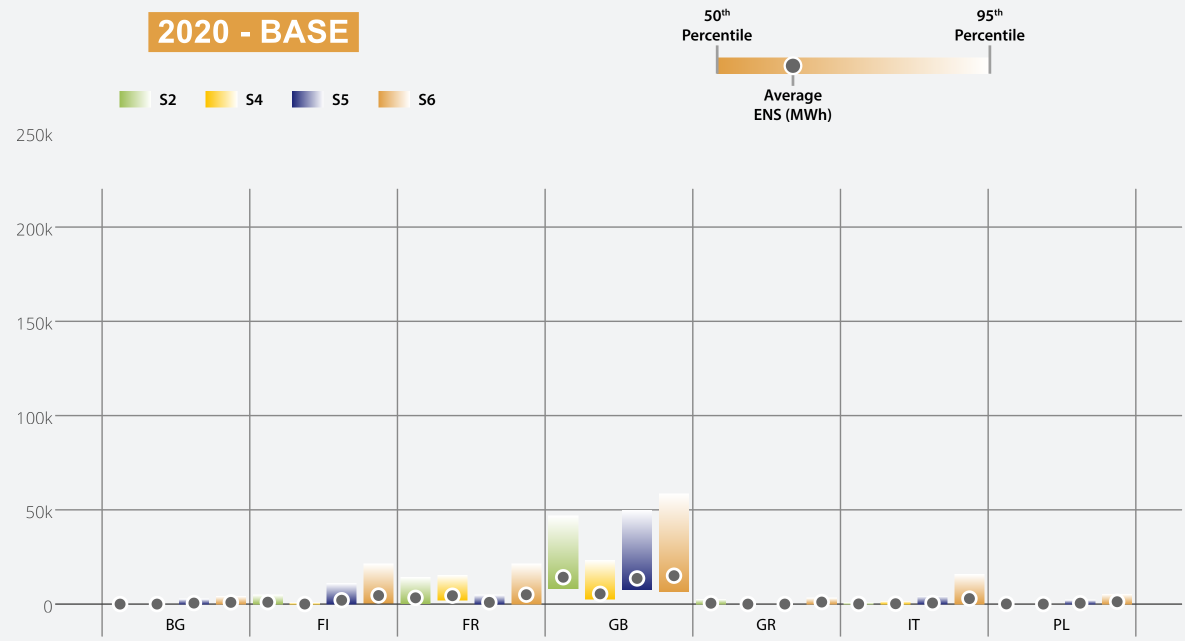
Both National Grid and ENTSO-E agree that the conservative interconnector assumptions are sensible for a Pan-European adequacy assessment. However, some factors that are specific to GB have not been fully accounted for in this adequacy assessment. The most important is that GB has a capacity market. This means that, in reality, the capacity shortfall in this analysis won't exist. The capacity market will ensure that GB has sufficient capacity to meet its reliability standard. In the context of this analysis, this means that if new interconnectors are delayed, then alternative forms of capacity will be successful in the capacity market auctions instead. These alternative forms of capacity have not been included in this assessment. Therefore the LOLE / ENS values reported for GB in the MAF should not be interpreted as an indication of potential adequacy problems.

The MAF 2016 results have to be strictly understood within the assumptions and data used in the respective simulations

MAP 2020



2020 - BASE



2020 Sensitivity Case I

MAIN MESSAGES

- These results provide an outlook of the main adequacy problems for a 2020 scenario assuming operational reserves contributing to adequacy on top of day-ahead (D-1) considerations.

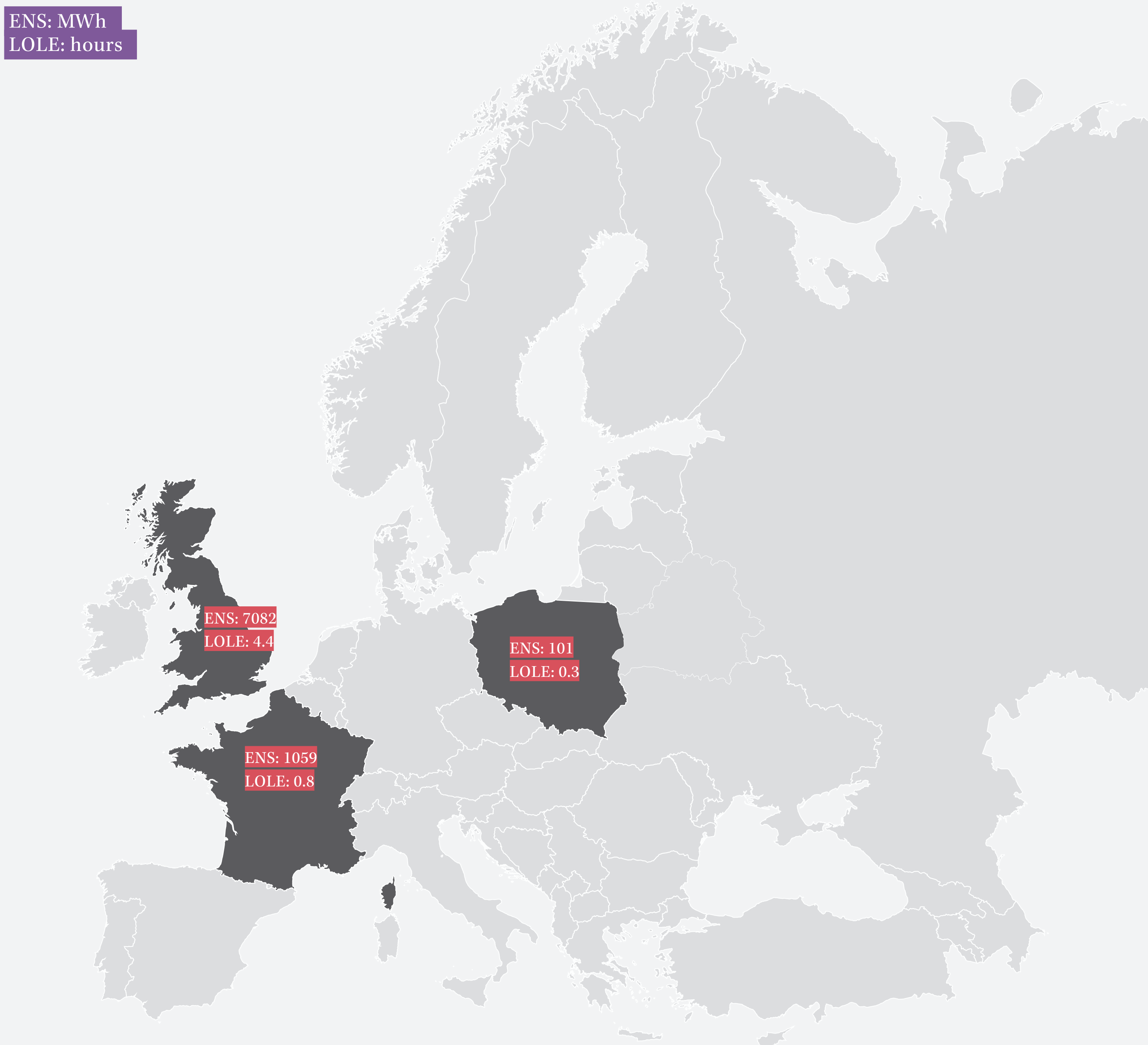
- The following country presents a LOLE > 1 h: GB, CY.

- GB Results: We refer to the explanations provided above. The reported LOLE / ENS values for GB in the MAF should not be interpreted as an indication of potential adequacy problems. The GB capacity market will ensure that sufficient capacity is available to meet its reliability standard.

- The contribution of operational reserves improves the adequacy situation with respect to the results provided in the Base Case.

- The results contained in this report should be understood strictly within the assumptions and data used in this chapter.

MAP 2020 SENSITIVITY CASE I



2020 Sensitivity Case II

MAIN MESSAGES

- These results provide an outlook of the main adequacy problems for a 2020 scenario assuming conservative NTC, operational reserves contribution to adequacy but considering the unavailability of cross-border capacity due to forced outages of selected HVDC interconnectors

- The following country presents an average LOLE >= 1 h: GB, FI, CY

- The contribution of operational reserves improves the adequacy situation with respect to the results provided in the Base Case. Unavailability of HVDC links increases ENS and LOLE for some countries.

- Results for GB: We refer to the explanations provided above for GB. Unsurprisingly, we also observe significant sensitivity of the main adequacy indicators ENS/LOLE to tha availability of interconnectors from GB to IE and continental Europe. However, such events are considered as part of the national analysis for the GB capacity market to ensure that sufficient capacity is available to meet its reliability standard.

- Results for FI: Finland relies on imports from its neighbours in scarcity situations. Unavailability of cross-border capacity of HVDC connections between FI and SE, and FI and EE, translates into adequacy problems.

- The results contained in this report should be understood strictly within the assumptions and data used in this chapter.

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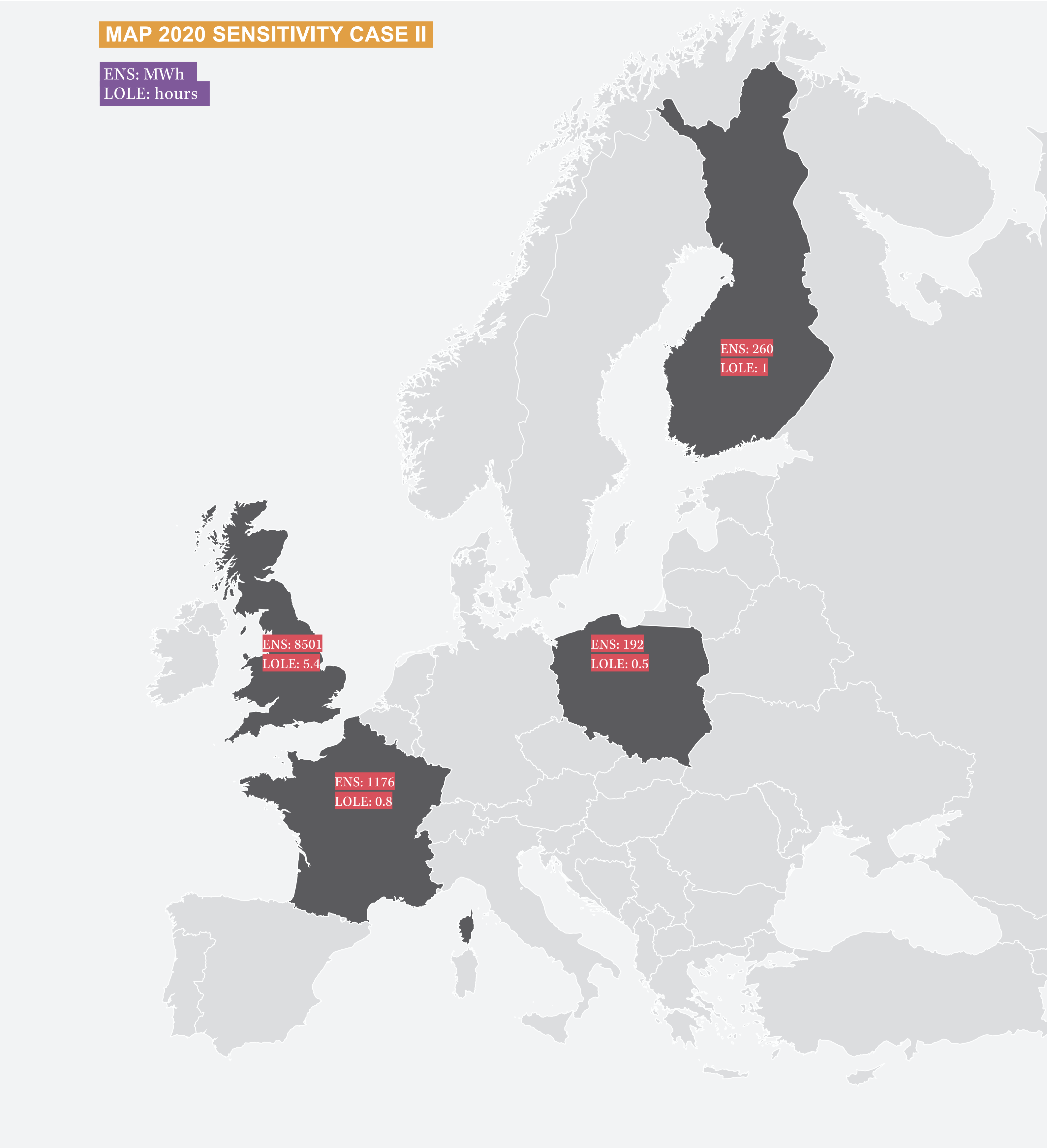

MAP 2020 SENSITIVITY CASE II
ENS: MWh
LOLE: hours
ENS: 260
LOLE: 1
ENS: 8501
LOLE: 5.4
ENS: 192
LOLE: 0.5
ENS: 1176
LOLE: 0.8

SUMMARY OF ADEQUACY INDICATORS (ENS AND LOLE) FOR 2025

The table below provides an overview of the values for Energy Non-Served (ENS) and Lost of Load expectation (LOLE) found for several countries within the Pan-European perimeter and within the different simulations performed in 2025. It is worth highlighting the following differences in the modelling assumptions between the different tools:

- (S2, S4) Hydro optimization includes perfect forecast knowledge of forced outages (FOR) of thermal units
- (S6) Hydro optimization assumes to have only the knowledge of forced outages rates (FOR) of thermal units applied as a reduction of production capability and not depending from *Monte Carlo* sampling.

2025 BASE CASE[7]				
COUNTRY	ENS (MWh)	COUNTRY	ENS (MWh)	Sim.
BE	30676	NI	3804	S2
	51809		3118	S6
CH	0	PL	27	S2
	11811		1332	S6
DE	894	LU	4579	S2
	38792		4103	S6
DK	2232	IT	8978	S2
	6174		26237	S6
FI	8436	NL	1061	S2
	28722		3618	S6
FR	60872	NO	0	S2
	150439		2360	S6
GB	19690	SE	330	S2
	26802		2109	S6
IE	3220	TR	577	S2
	4555		11	S6

[7] *For countries represented with more than one market node, LOLE for the aggregation is obtained considering the contemporaneity of ENS occurence rather than the sum of LOLE for each node.*

The differences of the results between tools do not strive from a lack of robustness of the results of (one or several of the) tools but the different optimization logic used by the different tools. We consider import to highlight the slight sensitivity of the results to these modelling features, with all data and other assumptions aligned between tools. In particular these differences in the results should be understood as a sensitivity in itself, which indicate the importance of flexible generation, in this case hydro power mainly, to react against both variability due to RES but also unavailability of thermal generation due to force outages.

The reason for the differences is because of the hydro-optimisation and thermal plants' forced-outages modelling. In a conservative setting (S6) one assumes that one has only prior-knowledge of fixed forced outages (independent from the actual Monte-Carlo draws) and also would not be able to adjust the dispatch after the forced outage is known, while in a less conservative setting (S2, S4) one assumes that one could foresee forced outages in advance and plan accordingly. This could respectively result in a different valuation of adequacy situations. In MAF this conservative setting by VP6 results in potentially tight conditions in regions with significant amount of hydro installed capacities. However, the reality is in between these two extreme cases, because even though forced outages, according to their definition, cannot be known well in advance in practice, but utilities should know soon after the outage starts and be able to re-optimise their schedules accordingly. For hydro-countries, utilities usually optimise their dispatch with a moving time-window, unlike a fixed window in the MAF simulations. With the well-known high flexibility of the hydro-plants they can adapt very quickly based on the prevailing market and system conditions. The results here presented should be understood strictly within the assumptions above presented.

2025 Base Case

MAIN MESSAGES

These results provide an outlook of the main adequacy problems for a 2025 scenario assuming operational reserves not contributing to adequacy (e.g. operational reserves constraints on top of day-ahead (D-1) market considerations)

The table above provides an overview of the average ENS and LOLE found after the probabilistic simulations. An increase in the occurrence of adequacy problems is observed in the 2025 scenario compared to the 2020 scenario.

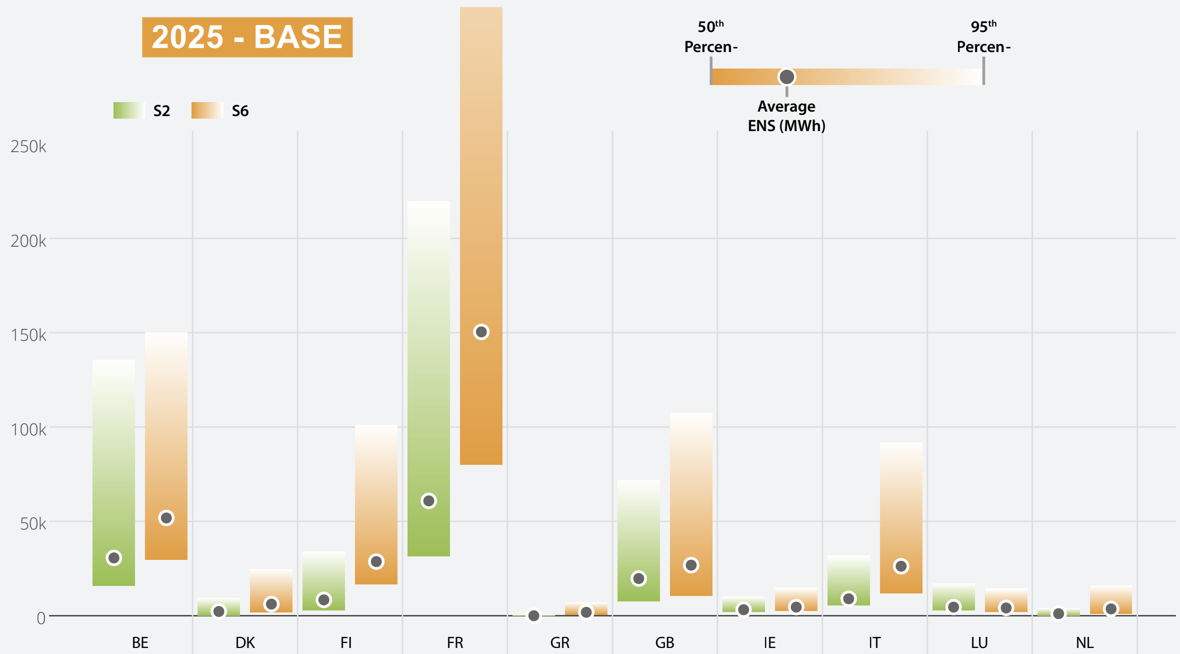
It should be noted that:

- a reduction of installed capacity of thermal power as well as an increase in RES is expected between 2020 and 2025 scenarios.
- demand at Pan-European level remains pretty stable (+1%) and does not seem to be the driver for adequacy issues.
- Conservative assumptions have been made regarding cross-border transmission capacity relating to uncertainty in the commissionning dates of cross-border transmission projects.

The sensitivity runs performed on the interrelation between hydro power dispatch, pumped storage flexibility and availability of thermal production shows the importance of flexibility in the future power system in tight situations combining scarcity of power and unavailability of thermal generation due to maintenance and faults. This sensitivity is especially relevant for countries like CH, PL and SE.

The results also highlight the need for increased cross-border transmission capacity.

The results contained in this report should be understood strictly within the assumptions and data used in this chapter



CONCLUSIONS

WHAT HAVE WE ACHIEVED?

- For the first time probabilistic methods have been used to assess risk to security of supply at the pan-European level
- The MAF gives the pan-European perspective that can later be used for additional regional and national studies

WHAT WE HAVE LEARNT?

- Need for a permanent group of transmission system operators' and experts to work on MAF
- Coordination and consistency between MAF and regional and national studies needs to be improved
- Information, knowledge and best practice exchange increase the quality of all outputs

WHAT WE COULD IMPROVE?

- Use the data of 35 climatic years instead of 14
- Improve assumptions on Net Transfer Capacity
- Model demand response
- Use flow-based methodology

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