Mid-term Adequacy Forecast

Appendix 1

DETAILED RESULTS, SENSITIVITIES AND INPUT DATA

2019 EDITION

entsoe
Reliable Sustainable Connected

Table of Contents

Abbreviations

CWE	Central Western Europe
DSR	Demand-Side Response
EENS	Expected Energy not Served
ENS	Energy not Served
FB	Flow-Based
FBMC	Flow-Based Market Coupling
FRR	Frequency Restoration Reserves
LC	Low-Carbon
LLD	Loss of Load Duration
LOLE	Loss of Load Expectation
MAF	Midterm Adequacy Forecast
NECP	National Energy and Climate Plan
NGC	Net Generating Capacity
NRA	National Regulatory Authority
NTC	Net Transfer Capacity
P50	50th Percentile
P95	95th Percentile
PEMMDB	Pan-European Market Modelling Database
RES	Renewable Energy Sources

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1 Overview of input data and scenarios

The input data for MAF 2019 is sourced from PEMMDB 3.0. More specifically, this report considers the years 2021 and 2025 and adds a Low-Carbon (LC) scenario for 2025. In total, MAF 2019 covers three scenarios. The following section will provide an overview of the input data for installed capacity for MAF 2019, point out trends and also compare the input data to the data used in MAF 2018.

Figure 1 to Figure 3 display the Net Generating Capacity (NGC) for all countries and the different scenarios by technology. As can be seen from the bar plots, Germany (DE), France (FR), Spain (ES) and Italy (IT) have the highest NGCs by 2025 at 237 GW, 160 GW, 130 GW and 115 GW, respectively. It should be noted that these total values are dominated by Renewable Energy Sources (RES) and hydro capacities, which becomes obvious in the plot of the shares of installed capacity for RES, hydro and non-RES on the map of Europe provided in Figure 4 and Figure 5. Here, it can also be seen that especially Iceland, Norway, Sweden, Switzerland and Austria have high shares of RES and hydro generation units in their power systems. In general, the share of RES rises from 2021 towards 2025 and increases further for the 2025 Low-Carbon scenario. At this point, however, it should be mentioned that the NGC of RES usually cannot be utilized fully for the provision of electrical energy.

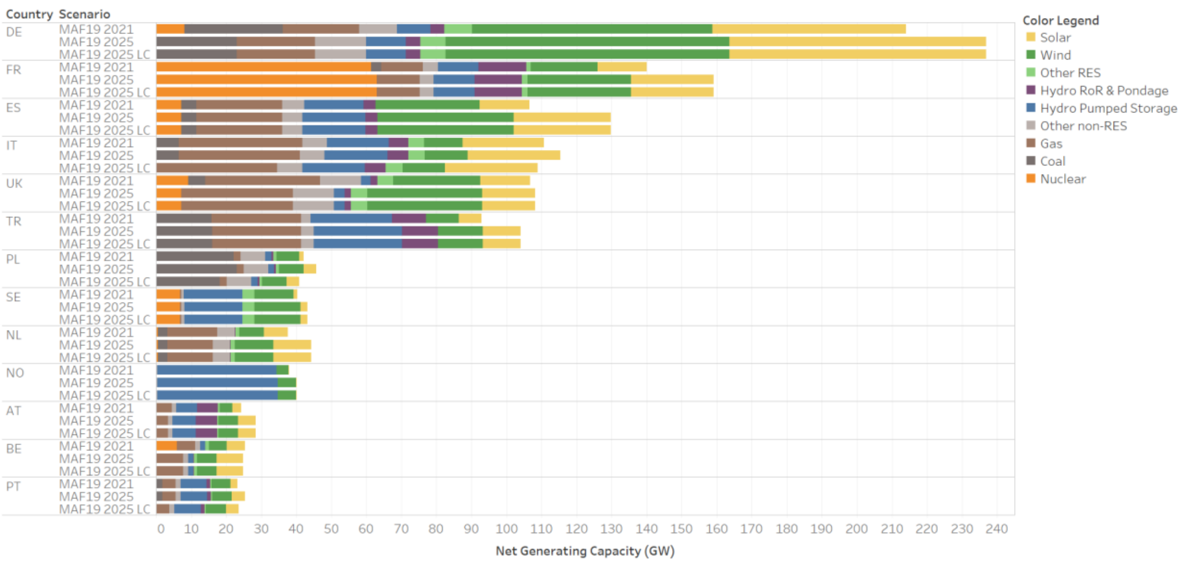

Figure 1: Net Generating Capacity (NGC) of MAF 2019 generating units for the 2021, 2025 and 2025 Low-Carbon scenarios (Part 1)

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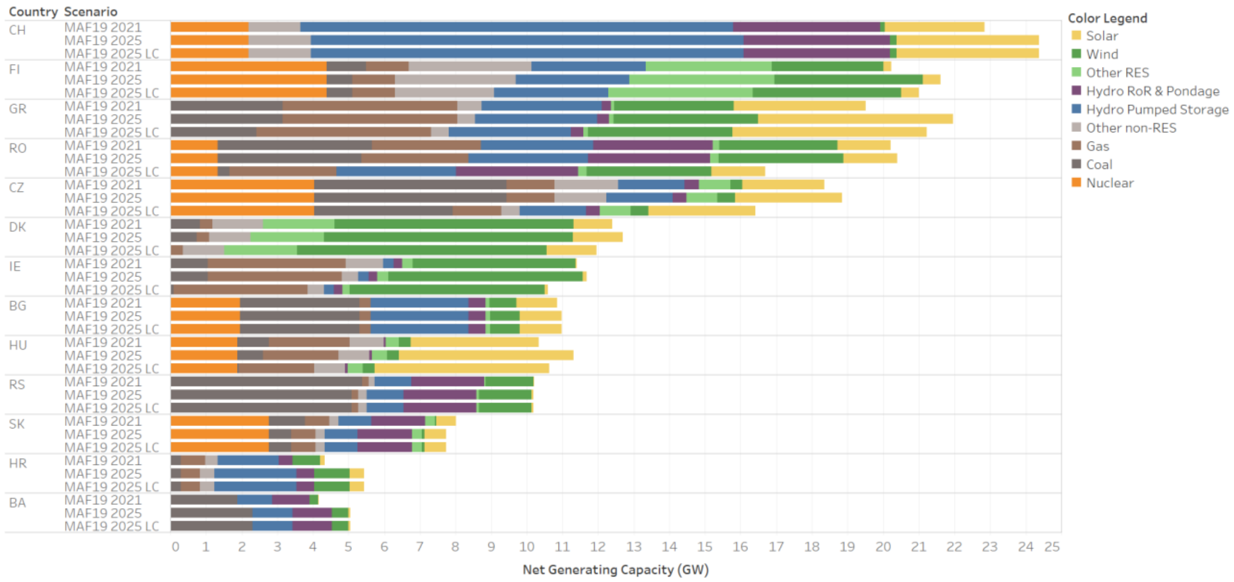

Figure 2: NGC of MAF 2019 generating units for the 2021, 2025 and 2025 Low-Carbon scenarios (Part 2)

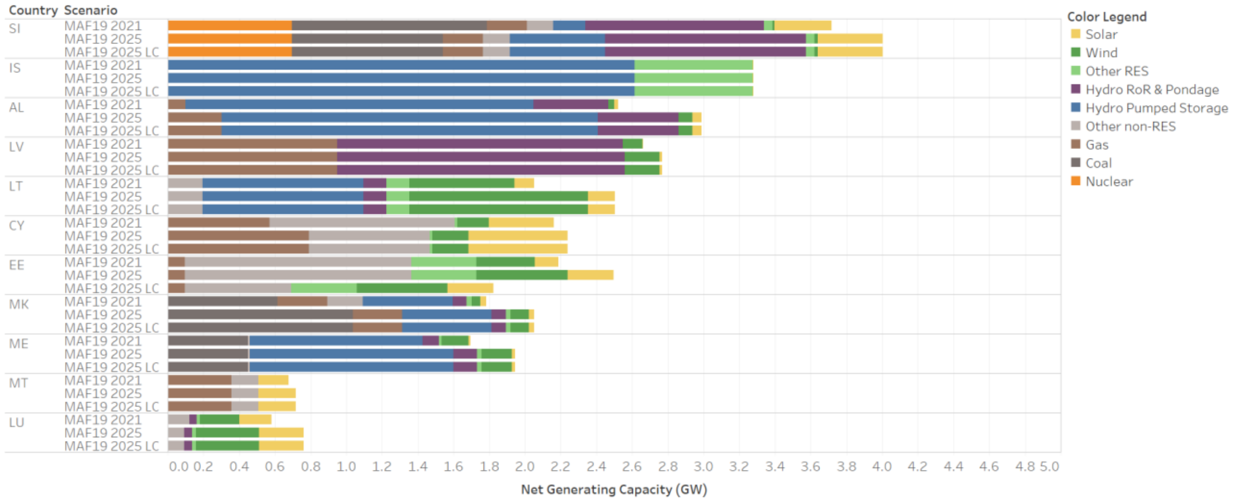

Figure 3: NGC of MAF 2019 generating units for the 2021, 2025 and 2025 Low-Carbon scenarios (Part 3)[1]

[1] Due to a data issue, the net generating capacity for **Lithuania** includes an additional 400 MW of hydro turbine capacity, which should have been reserved for FRR. Furthermore, according to the latest political decisions, exchanges with Russia from 2025 and after are not available, even though they were modelled in the MAF. These additional resources were compensated by the removal of all thermal generation in the model.

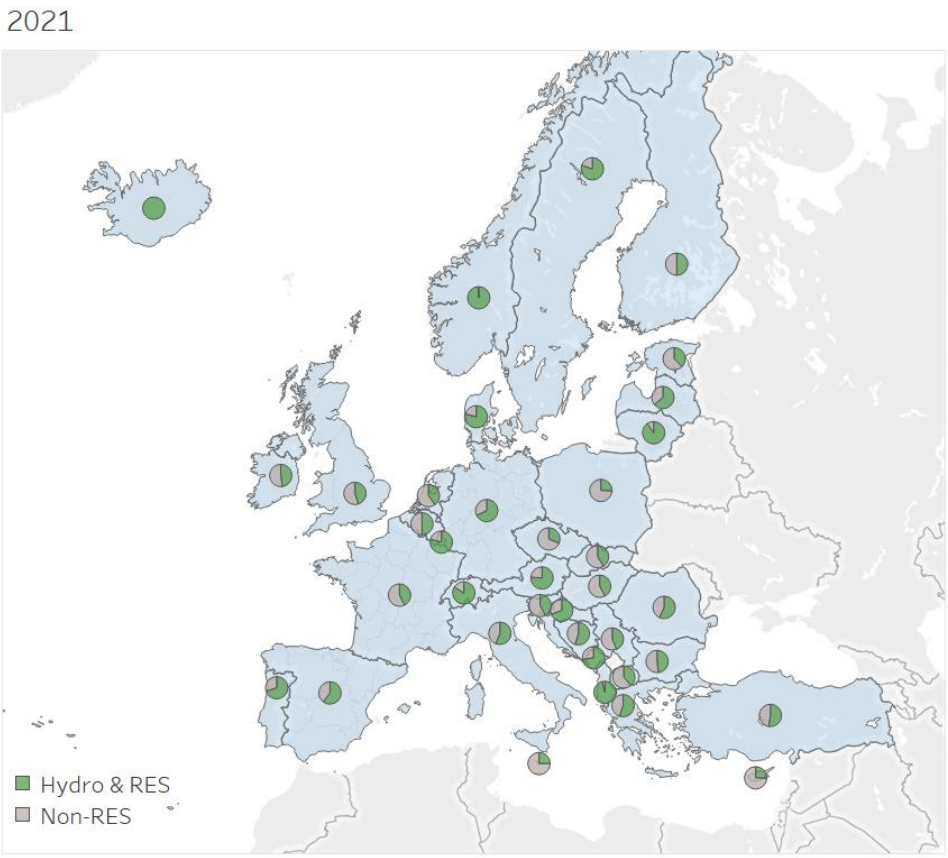

Figure 4: NGC shares of hydro and RES and non-RES for 2021

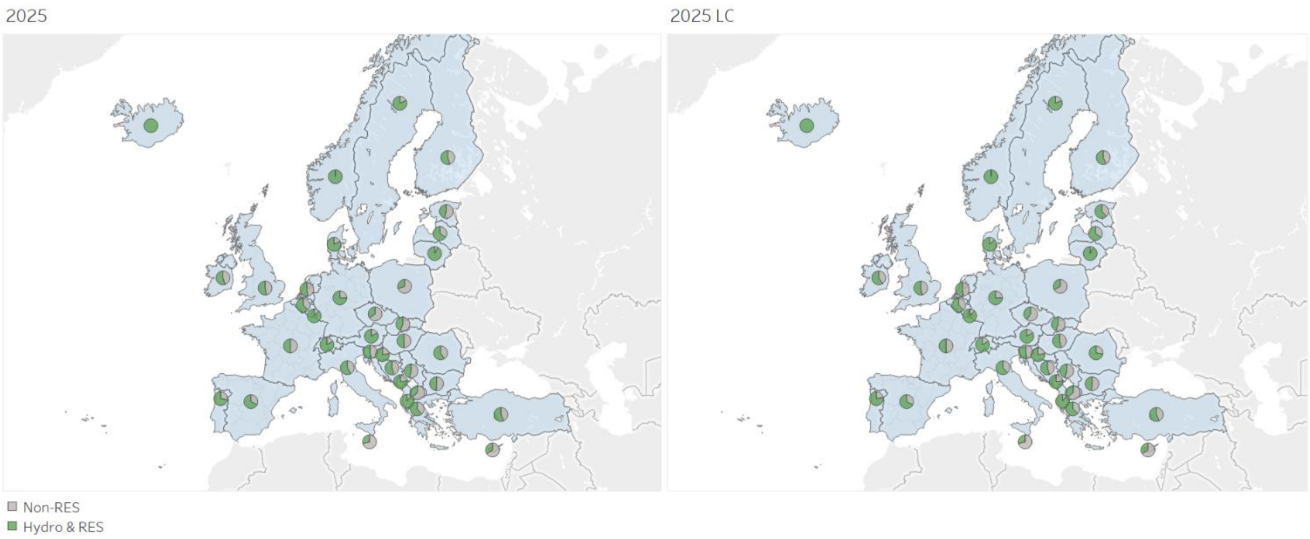

Figure 5: NGC shares of hydro and RES and non-RES for the 2025 and 2025 Low-Carbon scenarios

Taking a closer look at thermal generation, it is deduced from Figure 6 that, for 2021, the total NGC in Europe is dominated by France, Germany, Spain, Italy and the UK. In this context, thermal generation technologies include the following categories: gas, hard coal, lignite, oil, nuclear, waste and other non-RES. However, for 2025, the situation changes due to the large reduction in thermal power plant capacities, especially in Germany, Belgium and the UK. The reduction is due mainly to the planned decommissioning of nuclear and coal-fired power plants in these countries. The changes in installed capacity for thermal generation are shown as deltas between 2021 and 2025 and between 2021 and the 2025 Low-Carbon scenario in Figure 7.

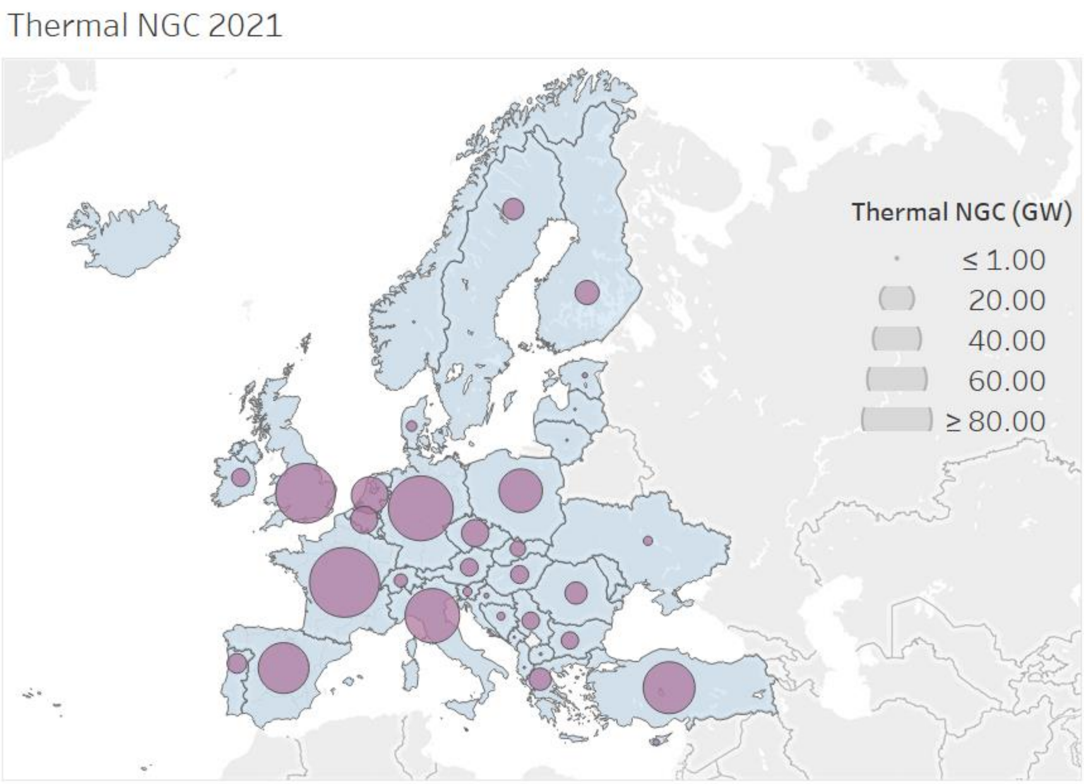

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Figure 6: NGC of thermal generating units in 2021

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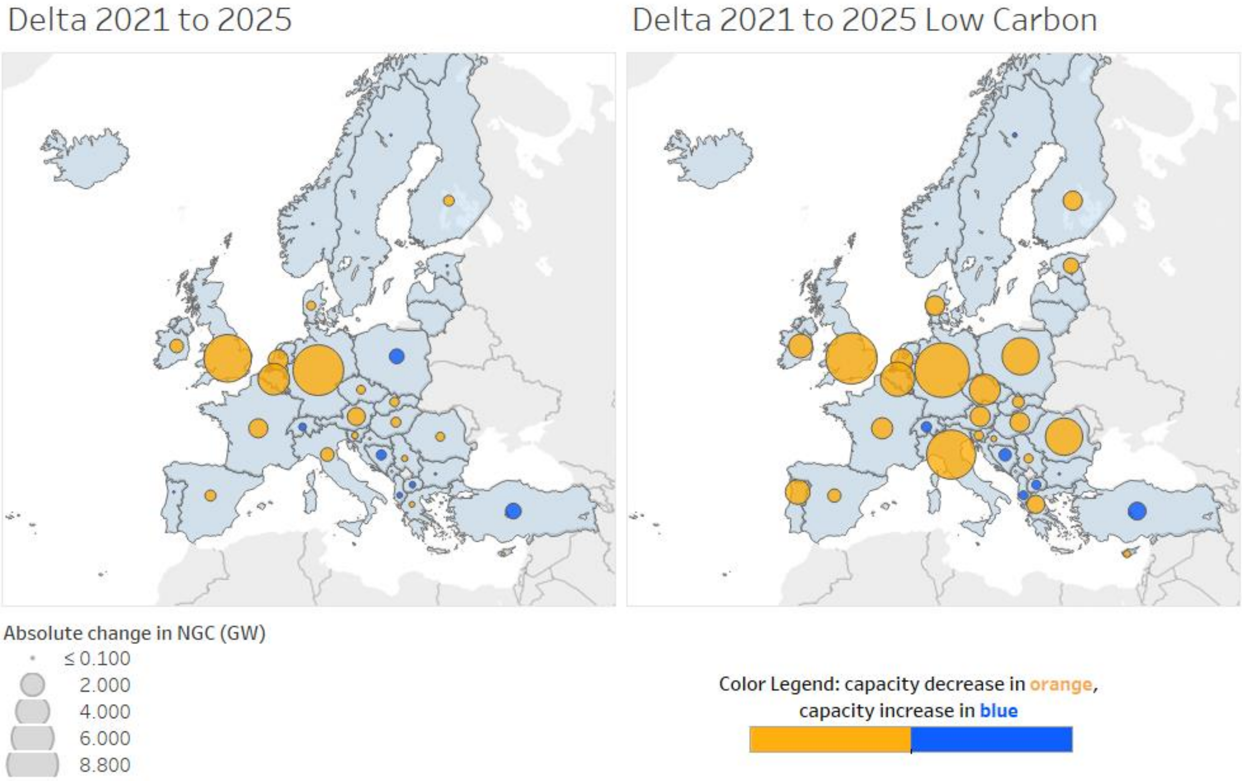

Figure 7: Changes in NGC of thermal generating units from 2021 to 2025 and from 2021 and the 2025 Low-Carbon scenario.

In the 2025 Low-Carbon scenario the following countries decrease their thermal generation fleet further: the Czech Republic, Finland, Estonia, Greece, Denmark, Italy, Hungary, Portugal, Romania, Ireland and Poland. In most cases, the decrease affects coal-fired plants for economic and / or political reasons. Figure 8 shows a more detailed visualization of the installed capacity of hard coal and lignite for all countries. The results of this scenario can be found in Section 4.

Regarding the comparison of the MAF 2018 and MAF 2019 input data, Figure 9 can be consulted for an overview. The stack charts show a direct comparison of the corresponding scenarios from MAF 2018 and MAF 2019. In general, the installed capacities for coal-fired plants tend to be lower in MAF 2019. The same holds for nuclear power plants, with the exception of France, where the targets for reducing the nuclear share in electricity production have been recently updated in the latest National Energy and Climate Plan (NECP) and indicate postponed shutdowns, leading to a nuclear generating capacity that is 4.5 GW higher for the 2025 scenario in MAF 2019 than in MAF 2018. For RES, the installed capacities are predominantly higher in the MAF 2019 scenarios. Hydro units do not differ significantly.

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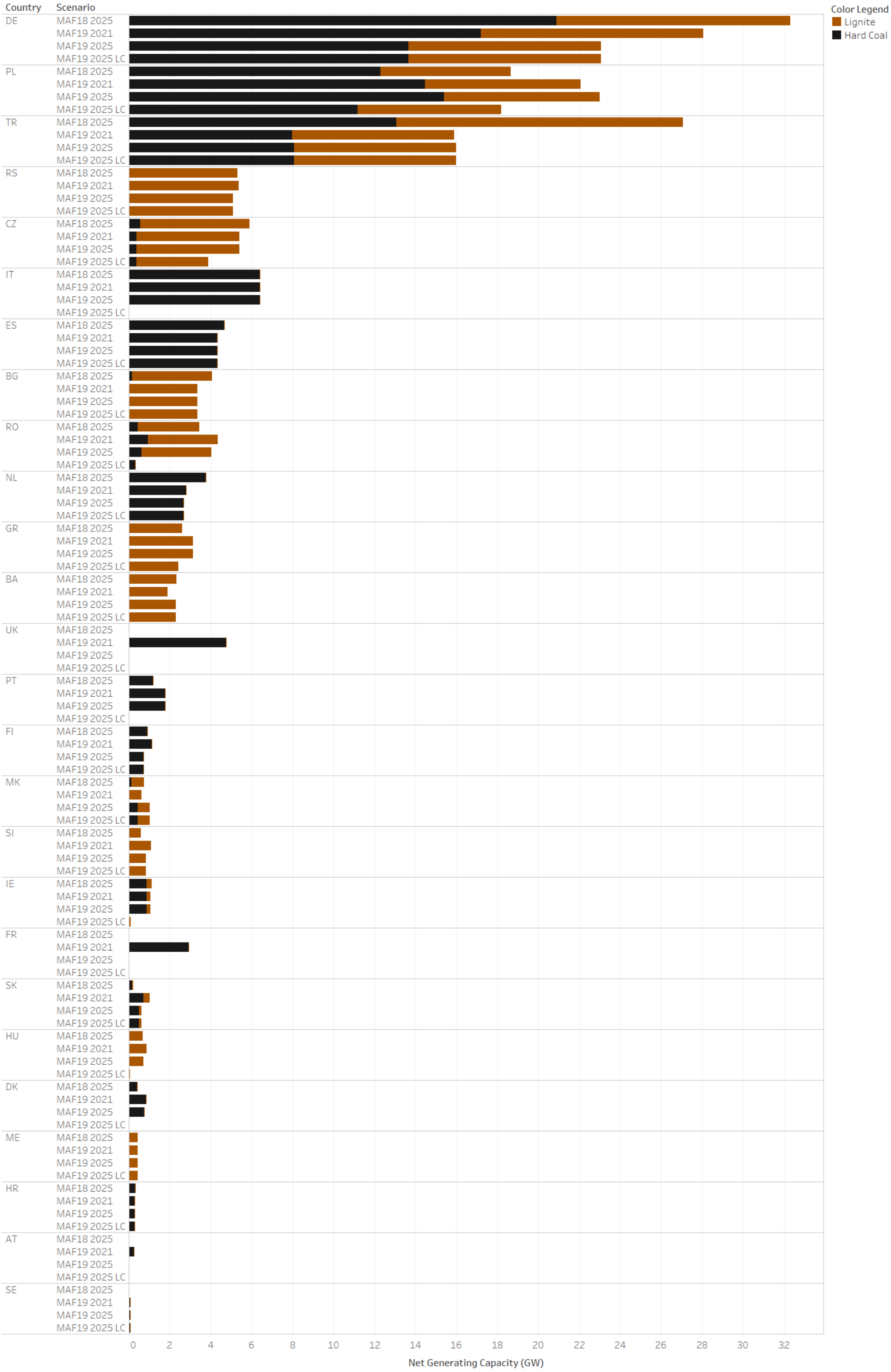

Figure 8: Installed capacity of coal-fired power plants for MAF 2018, target year 2025, and MAF 2019, target years 2021, 2025 and the 2025 Low-Carbon scenario

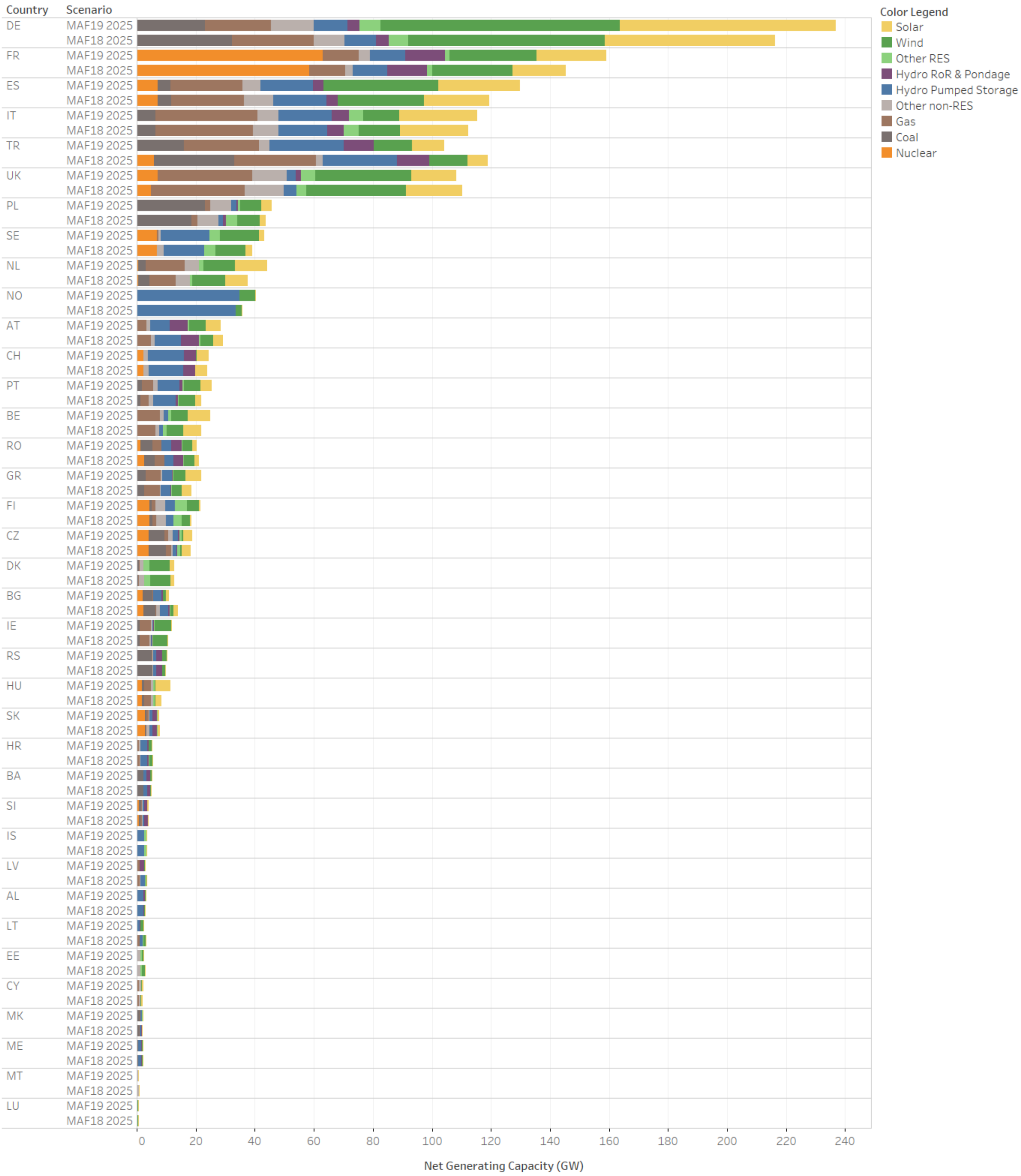

Figure 9: Comparison between projections for 2025 between MAF 2018 and MAF 2019

2 Adequacy in numbers: Base-Case results

The detailed results of the adequacy assessment for MAF 2019 are presented in this section. All results presented in the following tables are averages from the five different market modelling tools used for MAF and include:

- LOLE and EENS: mathematical expectations over the total number of Monte Carlo estimates;
- P50 of ENS and LLD: 50th percentile of the Monte Carlo estimates, i.e., 50% of the LLD/ENS estimates are above this value;
- P95 of ENS and LLD: 95th percentile of the Monte Carlo estimates, i.e., 5% of the LLD/ENS estimates are above this value;
- EENS / Annual Demand [%]: relative value of EENS with respect to the annual demand of the zone.

Results are presented in the form of detailed tables per market zone. Additionally, we present the aggregated results for some regions consisting of various zones:

- DK00: consisting of the zones DKE1, DKKF and DKW1;
- ISEM: consisting of the zones IE00 and UKNI;
- IT00: consisting of the zones ITCN, ITCS, ITN1, ITS1, ITSA and ITSI;
- NO00: consisting of the zones NOS0, NOM1 and NON1;
- SE00: consisting of the zones SE01, SE02, SE03 and SE04.

Table 1: EENS [GWh] results for Base-Case scenarios for 2021 and 2025 by zone[2]

Market Zone	Base-Case scenario 2021				Base-Case scenario 2025			
	EENS [GWh]	EENS / Annual Demand	P50 [GWh]	P95 [GWh]	EENS [GWh]	EENS / Annual Demand	P50 [GWh]	P95 [GWh]
AL00	-	-	-	-	-	-	-	-
AT00	-	-	-	-	0.04	-	-	-
BA00	-	-	-	-	-	-	-	-
BE00	0.68	0.001%	-	0.31	1.18	0.001%	-	3.50
BG00[3]	-	-	-	-	-	-	-	-
CH00	0.08	-	-	-	0.37	-	-	-
CY00	0.03	-	-	0.11	0.88	-	0.53	2.96
CZ00	-	-	-	-	0.03	-	-	-
DE00	0.03	-	-	-	1.23	-	-	2.07
DEKF	-	-	-	-	-	-	-	-
DK00	0.14	-	-	0.04	0.28	-	0.01	0.58
DKE1	0.14	0.001%	-	0.06	0.32	0.001%	-	1.19
DKKF	-	-	-	-	-	-	-	-
DKW1	-	-	-	-	-	-	-	-

[2] Outliers were removed from zones FR00, ITSI, NOS1 and MT00 in the 2021 results and zones CY00, ITSI, LT00 and TR00 in the 2025 results.
[3] Note that in this study, demand data for Bulgaria include auxiliary consumption of power plants.

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Market Zone	Base-Case scenario 2021				Base-Case scenario 2025			
	EENS [GWh]	EENS / Annual Demand	P50 [GWh]	P95 [GWh]	EENS [GWh]	EENS / Annual Demand	P50 [GWh]	P95 [GWh]
EE00	0.12	0.001%	0.03	0.27	0.05	0.001%	-	0.18
ES00	-	-	-	-	-	-	-	-
FI00	0.06	-	-	0.21	-	-	-	-
FR00	17.76	0.004%	-	38.41	13.87	0.004%	-	19.43
GR00	-	-	-	-	-	-	-	-
GR03	0.02	0.001%	-	0.11	-	0.001%	-	-
HR00	-	-	-	-	-	-	-	-
HU00	-	-	-	-	-	-	-	-
ISEM	-	-	-	0.01	0.43	-	0.08	0.88
IE00	-	-	-	-	0.46	-	0.07	2.00
IS00	-	-	-	-	0.19	-	0.03	0.56
IT00	4.53	0.001%	0.16	13.63	7.53	0.001%	0.75	10.14
ITCN	1.33	0.004%	-	5.72	1.85	0.004%	-	5.61
ITCS	-	-	-	-	-	-	-	-
ITN1	1.67	0.001%	-	2.42	4.46	0.001%	-	4.95
ITS1	-	-	-	-	-	-	-	-
ITSA	0.02	-	-	0.10	0.01	-	-	0.06
ITSI	1.64	0.008%	-	10.11	2.85	0.008%	0.78	12.33
LT00	0.56	0.005%	-	1.03	2.42	0.004%	0.37	10.66
LUG1	0.12	0.002%	-	-	0.74	0.002%	-	2.95
LV00	0.19	0.003%	0.01	0.26	0.14	0.002%	0.01	0.37
ME00	-	-	-	-	-	-	-	-
MK00	-	-	-	-	-	-	-	-
MT00	8.51	0.342%	7.43	17.19	13.25	0.316%	12.37	22.54
NL00	-	-	-	-	-	-	-	-
NO00	1.38	0.001%	-	0.03	0.05	0.001%	-	-
NOM1	0.04	-	-	0.01	-	-	-	-
NON1	-	-	-	-	-	-	-	-
NOS0	1.34	0.001%	-	0.01	0.05	0.001%	-	-
PL00	0.79	-	0.12	3.23	0.01	-	-	-
PT00	-	-	-	-	-	-	-	-
RO00	-	-	-	-	-	-	-	-
RS00	-	-	-	-	-	-	-	-
SE00	2.51	0.002%	-	0.06	0.48	0.002%	-	-
SE01	-	-	-	-	-	-	-	-
SE02	-	-	-	-	-	-	-	-
SE03	0.49	0.001%	-	-	0.04	0.001%	-	-
SE04	2.16	0.009%	-	0.01	0.68	0.009%	-	-
SI00	-	-	-	-	-	-	-	-
SK00	-	-	-	-	-	-	-	-

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Market Zone	Base-Case scenario 2021				Base-Case scenario 2025			
	EENS [GWh]	EENS / Annual Demand	P50 [GWh]	P95 [GWh]	EENS [GWh]	EENS / Annual Demand	P50 [GWh]	P95 [GWh]
TR00	0.02	-	-	0.03	27.85	-	25.22	57.15
UK00	-	-	-	-	-	-	-	-
UKNI	-	-	-	0.01	0.08	-	-	0.34

Table 2: LOLE [h/year] results for Base-Case scenarios for 2021 and 2025 by zone[4]

Market Zone	Base-Case scenario 2021			Base-Case scenario 2025		
	LOLE [h/year]	P50 [h/year]	P95 [h/year]	LOLE [h/year]	P50 [h/year]	P95 [h/year]
AL00	-	-	-	-	-	-
AT00	-	-	-	0.02	-	-
BA00	-	-	-	-	-	-
BE00	0.91	-	0.72	1.09	-	3.15
BG00[5]	0.01	-	-	-	-	-
CH00	0.08	-	-	0.27	-	-
CY00	0.61	0.03	2.54	15.64	12.32	40.55
CZ00	-	-	-	0.05	-	-
DE00	0.02	-	-	0.29	-	1.01
DEKF	-	-	-	-	-	-
DK00	0.48	-	0.30	0.80	0.04	2.60
DKE1	0.39	-	0.65	0.67	-	3.20
DKKF	-	-	-	-	-	-
DKW1	-	-	-	0.01	-	-
EE00	0.74	0.40	1.67	0.40	0.20	1.04
ES00	-	-	-	-	-	-
FI00	0.18	-	0.72	-	-	-
FR00	4.12	-	17.14	2.75	-	6.87
GR00	-	-	-	-	-	-
GR03	0.71	0.03	4.59	-	-	-
HR00	-	-	-	-	-	-
HU00	-	-	-	-	-	-
ISEM	0.03	0.02	0.06	1.79	0.81	5.98
IE00	-	-	-	2.03	0.82	8.46
IS00	-	-	-	0.27	0.20	0.80
IT00	6.86	1.21	25.34	12.11	5.15	26.37
ITCN	2.05	-	7.69	2.51	-	7.79

[4] Outliers were removed from zones FR00, ITSI, NOS1 and MT00 in the 2021 results and from zones CY00, ITSI, LT00 and TR00 in the 2025 results.

[5] Note that in this study, demand data for Bulgaria include auxiliary consumption of power plants.

Market Zone	Base-Case scenario 2021			Base-Case scenario 2025		
	LOLE [h/year]	P50 [h/year]	P95 [h/year]	LOLE [h/year]	P50 [h/year]	P95 [h/year]
ITCS	-	-	-	-	-	-
ITN1	0.74	-	2.66	1.54	-	4.24
ITS1	-	-	-	-	-	-
ITSA	0.23	-	1.04	0.13	-	0.83
ITSI	4.22	-	25.75	8.97	4.50	32.76
LT00	1.46	-	3.62	7.48	3.00	29.52
LUG1	0.17	-	0.01	0.89	-	3.49
LV00	1.12	0.20	1.73	1.02	0.25	4.08
ME00	-	-	-	-	-	-
MK00	-	-	-	-	-	-
MT00	158.23	147.86	278.89	246.59	236.66	365.11
NL00	-	-	-	0.01	-	0.01
NO00	0.87	-	0.47	0.04	-	-
NOM1	0.12	-	0.20	-	-	-
NON1	-	-	-	-	-	-
NOS0	0.64	-	0.25	0.02	-	-
PL00	1.35	0.17	6.23	0.03	-	-
PT00	-	-	-	-	-	-
RO00	-	-	-	-	-	-
RS00	-	-	-	-	-	-
SE00	2.18	-	0.19	0.77	-	0.01
SE01	-	-	-	-	-	-
SE02	-	-	-	-	-	-
SE03	0.49	-	-	0.08	-	-
SE04	1.74	-	0.03	0.62	-	-
SI00	-	-	-	-	-	-
SK00	-	-	-	-	-	-
TR00	0.04	-	0.05	23.71	22.23	43.93
UK00	-	-	-	-	-	-
UKNI	0.03	-	0.22	0.60	0.06	2.61

3 Flow-Based sensitivity for 2021 – focusing on Central Western Europe (CWE)

The Flow-Based (FB) approach was implemented as a sensitivity for the year 2021, following the implementation of Flow-Based Market Coupling (FBMC) performed at the regional level in the PLEF study[6]. The approach for FBMC is an important step towards the more realistic modelling of the operational planning in practice nowadays. In this approach, representative historical FB domains are implemented for Central Western Europe (CWE) countries (AT, BE, DE, FR, NL) as a basis for modelling cross-border capacity while considering the effect of grid reinforcements up until 2019. The different types of FB domains used represent several situations with different levels of grid congestion. Their implementation in the model is further correlated to expected climate and consumption conditions for each day of the simulations, which are the main drivers for grid congestion. The methodology of the FB analysis is presented in detail in Appendix 2.

The simulations for the 2021 case have been performed using three market modelling tools: one FB model was built based on PEMMDB 3.0 (i.e., unit-by-unit thermal power plant data), and two models were built based on PEMMDB 2.1 (similar power plant clustering to those in PLEF and MAF 2018). FB modelling is a milestone for MAF, since the implementation of the "Clean Energy Package" will require that future adequacy assessments replace the Net Transfer Capacity (NTC) approach with FB wherever possible.

The FB approach is generally in line with the Base-Case results of the NTC approach for this study, leading, however, to some changes in the CWE region and neighbouring zones (BE00, CH00, FR00, ITCN, ITN1, LUG1). Figure 10 and Figure 11 present a comparison of the results between the Base-Case NTC approach and the FB sensitivity for the aforementioned zones. As observed, an increase in LOLE and EENS values appears in Belgium under the FB approach. To the contrary, the results of the FB sensitivity for France showcase a marginal decrease in terms of LOLE when FB is considered. Regarding the EENS of France, the decrease is almost negligible. The FB implementation in the CWE region affects the Italian zones as well but without a common trend: results for Continental North Italy show a small decrease in LOLE, while Italy North is affected negatively, i.e., by an increase in scarcity hours, via the implementation of FB. However, the impact of FB implementation in this particular study is not significant, except in the case of Belgium.

[6] Pentalateral Energy Forum, Support Group 2, "Generation Adequacy Assessment", January 2018, http://www.benelux.int/nl/kernthemas/holder/energie/pentalateral-energy-forum

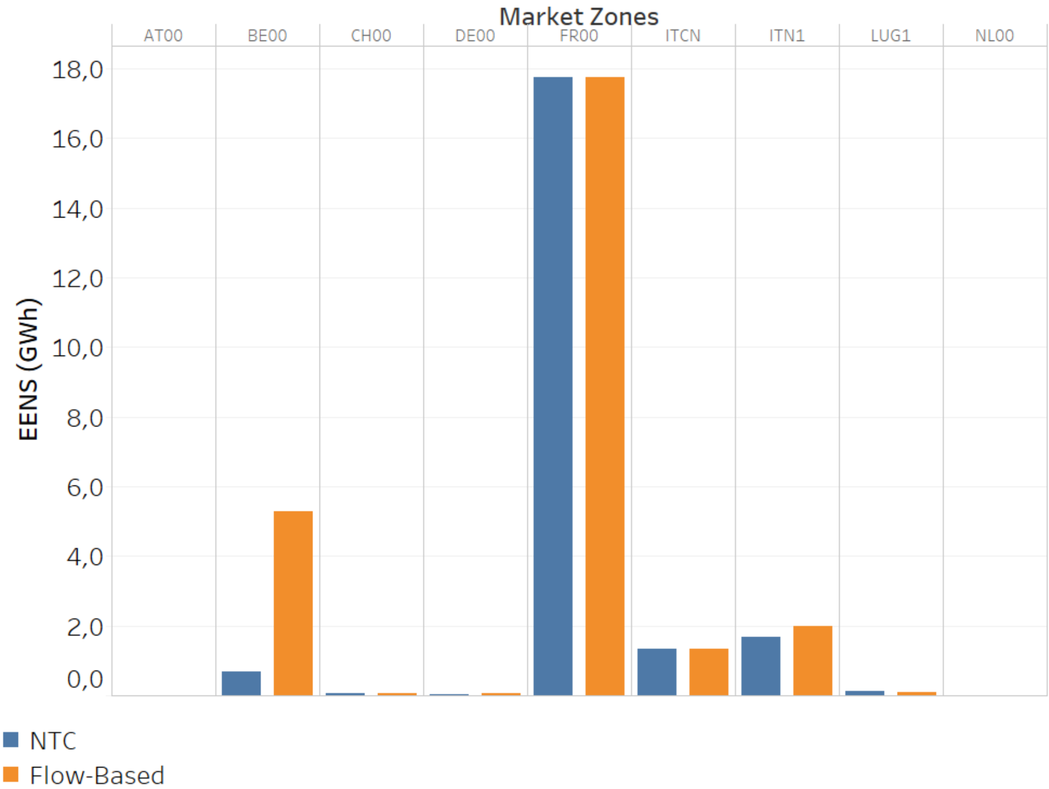

Figure 10: EENS Flow-Based vs. NTC results for target year 2021. Just CWE and affected neighbouring zones are presented in this graph.

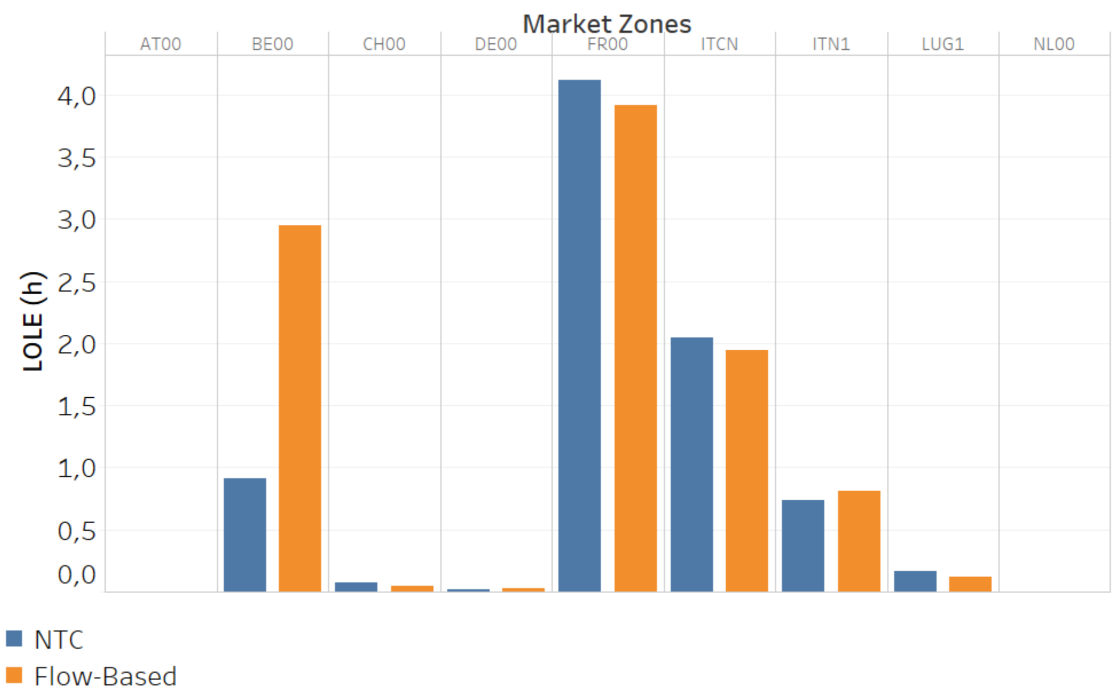

Figure 11: LOLE Flow-Based vs. NTC results for target year 2021. Just CWE and affected neighbouring zones are presented in this graph.

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The reason that the results of the FB simulation for 2021 are not significantly different from the NTC results could be related (although not exclusively) to the effect of the MinRAM 20% implementation, which allows an increased capacity to be offered to the market during the Capacity Calculation stage, as opposed to the situation prior to such an implementation, within the CWE FBMC. However, the higher LOLE values observed in FB as opposed to NTC in the case of Belgium stem from the more accurate modelling of the network, which allowed the interdependencies between commercial exchanges in neighbouring countries and the physical flows occurring in the grid to be captured. Such interdependencies are important when modelling, for example, cases of so-called 'simultaneous scarcity'.

4 Low-Carbon sensitivity for 2025

In addition to the Base-Case scenarios, data were collected concerning the number and size of generation units potentially at risk of being decommissioned by 2025 due to an acceleration of "Low-Carbon (environmental) policies". Such capacity reductions could stem either directly from environmental legislations – e.g., a coal phase-out – or indirectly via the impact of environmental actions impacting the profitability of generating units. This study constitutes a **stress test**, since the decommisionned generation capacity considered in this assessment is not replaced by any other resource.

The motivation behind this scenario is manifold:

- Carbon pricing and relevant policies have an important impact on the generation fleet and adequacy of multiple zones;
- Changes in a political level lead to expected updates in the national plans regarding decreased use of coal and lignite. Thus, for some zones, this scenario is consistent with updated or expected updates in the NECP that are not accounted for in the Base-Case scenario (e.g., Greece and Italy);
- It is a scenario of specific interest to the National Regulatory Authorities (NRAs);
- The corresponding scenario in MAF 2018 was well-received by stakeholders, thus we considered it useful to update the results of such a stress test.

The input was provided by TSOs, and the reduced capacity in comparison with the Base-Case 2025 is presented in absolute numbers (GW) in Table 3. In total, around 23.6 GW of generating capacity were removed from the 2025 Base-Case scenario, mainly through reductions in lignite and hard coal capacities.

Table 3: Net generating capacity flagged as at risk of being de-commissioned by 2025 and consequently removed in the Low-Carbon sensitivity analysis

Country	Lignite capacity [GW]		Hard coal capacity [GW]		Total removed capacity
	Base-Case	Low-carbon	Base-Case	Low-Carbon	
Estonia	-	-	-	-	0.7*
Czech	5.0	3.5	0.4	0.4	2.4*
Denmark	-	-	1.5	0.8	0.7
Finland	-	-	1.9	1.9	0.6*
Greece	3.1	2.4	-	-	0.7
Hungary	0.7	0	0.2	0.2	0.7
Ireland	0.4	0.2	0.9	0	1.1
Italy	-	-	6.4	0	6.4
Poland	7.6	7.0	15.8	11.5	4.8
Portugal	-	-	1.8	0	1.8
Romania	3.4	0	0.6	0.3	3.7

* A portion of the removed net generating capacity is from technologies other than lignite or hard coal

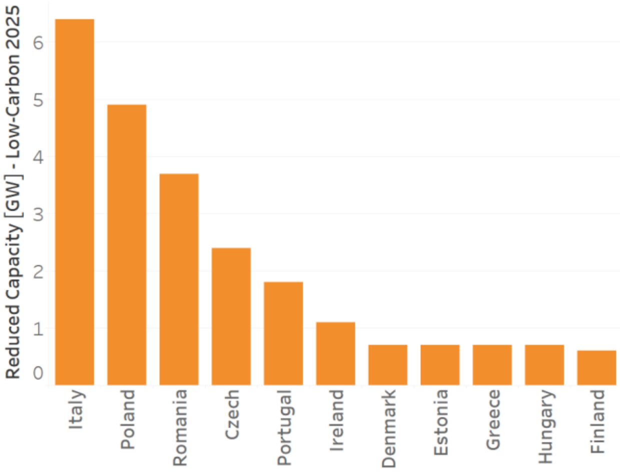

Figure 12: Reduced capacity per country in the Low-Carbon sensitivity for target year 2025

The regional dimension of adequacy is confirmed by this stress test analysis: Figure 13 and Figure 14 show a comparison between the LOLE and EENS results per country in the Base-Case scenario and the Low-Carbon scenario. Countries with very small LOLE values in the Low-Carbon scenario were ommited from the graph (e.g., PT00 and GR00).

It is observed from Figure 13 that the decreased capacities in Ireland, Estonia and Poland lead to increased LOLE and EENS values under this scenario. Furthermore, zones that depend to these zones for imports are also affected considerably by this scenario, e.g., Lithuania and Latvia. Lastly, all coal capacity has been removed from Italian zones, which has a considerable impact on the EENS and LOLE values, especially in the zone of Sardinia.

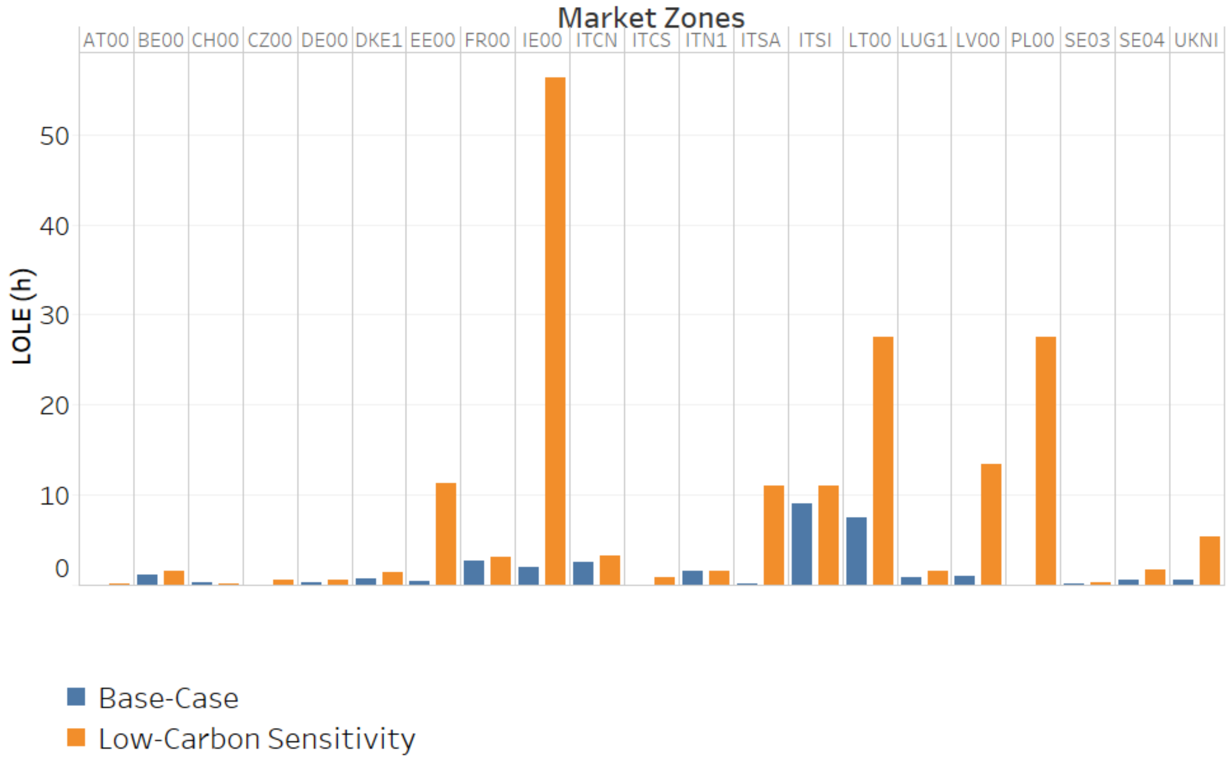

Figure 13: Comparison of LOLE values between the Base-Case and the Low-Carbon scenarios in 2025. The graph includes only zones with LOLE values above 0.5h.

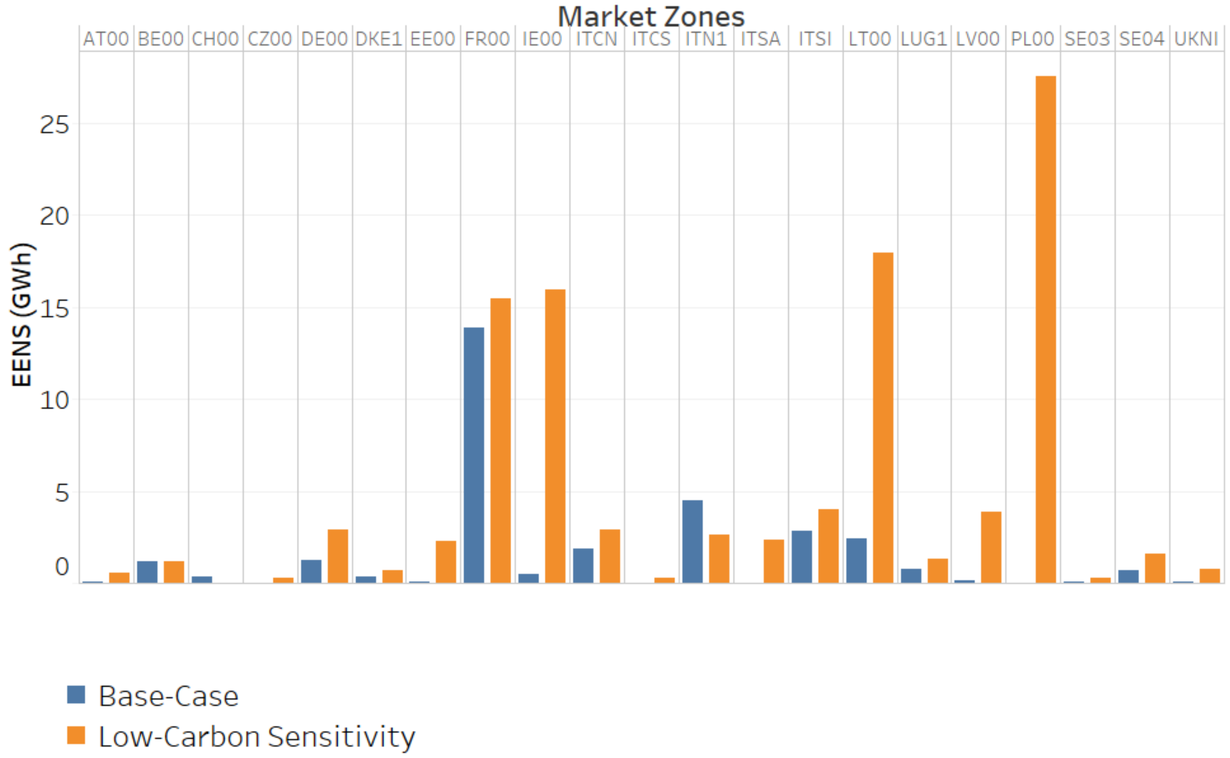

Figure 14: Comparison of EENS between the Base Case and the Low-Carbon sensitivity in 2025. The graph includes all zones with LOLE values above 0.5h.

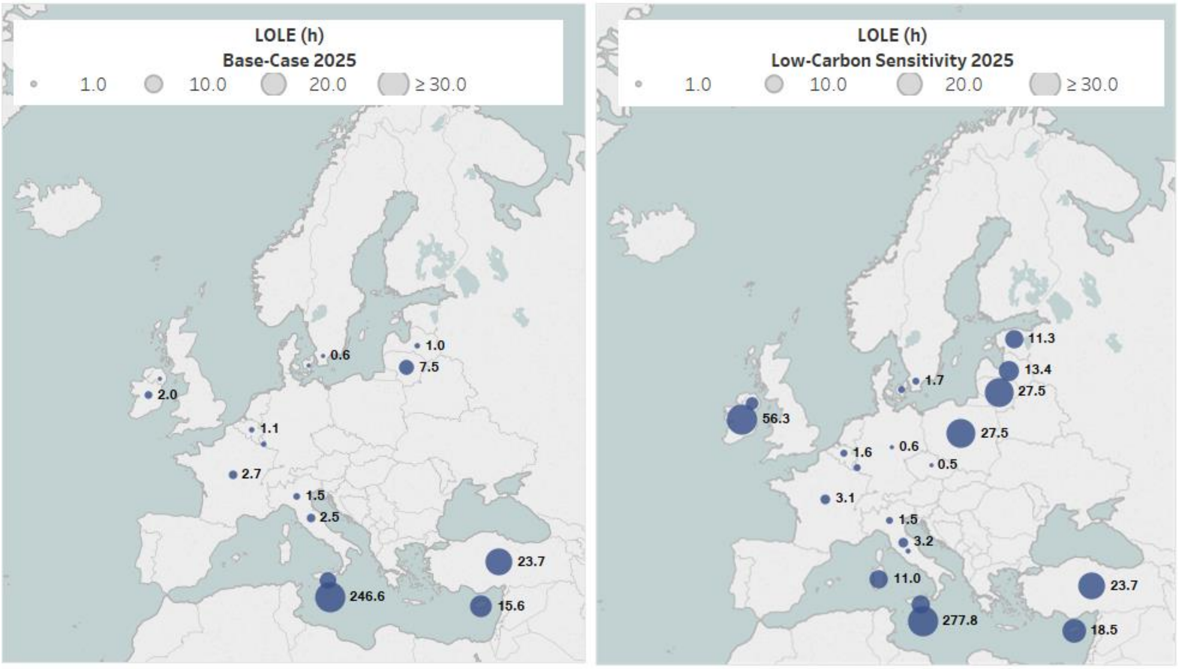

Figure 15: Comparison of LOLE values between the Low-Carbon and Base-Case for 2025. The map includes only zones with LOLE values above 0.5h.

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An overview of the LOLE and EENS results per country for the Low-Carbon sensitivity are shown in Table 4.

Table 4: EENS and LOLE Low-Carbon sensitivity results for 2025 per country

Market Zone	LOLE [h/year]	EENS [GWh]	Market Zone	LOLE [h/year]	EENS [GWh]	Market Zone	LOLE [h/year]	EENS [GWh]
AL00	0.01	-	HR00	0.01	-	NOM1	-	-
AT00	0.11	0.33	HU00	0.09	0.02	NON1	-	-
BA00	-	-	ISEM	57.73	21.05	NOS0	-	-
BE00	1.61	2.07	IE00	56.33	20.35	PL00	27.50	23.29
BG00	-	-	IS00	-	-	PT00	-	-
CH00	0.18	0.58	IT00	24.00	12.70	RO00	0.04	0.01
CY00	18.46	1.04	ITCN	3.20	3.16	RS00	0.01	-
CZ00	0.50	0.44	ITCS	0.88	0.50	SE00	1.68	2.17
DE00	0.59	2.40	ITN1	1.49	2.87	SE01	-	-
DEKF	-	-	ITS1	-	-	SE02	-	-
DK00	1.43	0.72	ITSA	10.96	2.04	SE03	0.34	0.23
DKE1	1.41	0.68	ITSI	11.07	4.00	SE04	1.66	1.91
DKKF	-	-	LT00	27.46	14.35	SI00	0.04	-
DKW1	0.11	0.03	LUG1	1.55	1.28	SK00	0.03	-
EE00	11.29	1.99	LV00	13.37	2.22	TR00	23.70	27.85
ES00	-	-	ME00	-	-	UA01	-	-
FI00	0.16	0.04	MK00	-	-	UK00	0.01	-
FR00	3.13	16.53	MT00	277.82	14.88	UKNI	5.39	0.70
GR00	-	-	NL00	0.01	-			
GR03	0.01	-	NO00	-	-			

This sensitivity analysis should be understood as a stress test on generating capacity, and can, by definition, only result in inferior adequacy levels. The results confirm that the decommissioning of polluting generation capacity should be accompanied in some zones by the development of alternative generating capacity, e.g., development of demand-side response (DSR), storage, generation, interconnection). Higher granularity of national/regional adequacy assessments could complete the picture by assessing possible resource adjustments and detecting any local resources or network constraints which might not have been identified by the MAF. Also, the next edition of the MAF will strive to monitor the situation further through possible updates of the assumptions made for each country.

Finally, to ensure reliable predictions of future adequacy levels, it is crucial to obtain reliable and consistent data from the supply side of the system. To this end, a potential approach could be to ask European utilities to announce their (de-)commissioning and mothballing plans for 3–5 years ahead. Doing so would result in a clearer picture of future system conditions and power system evolutions.

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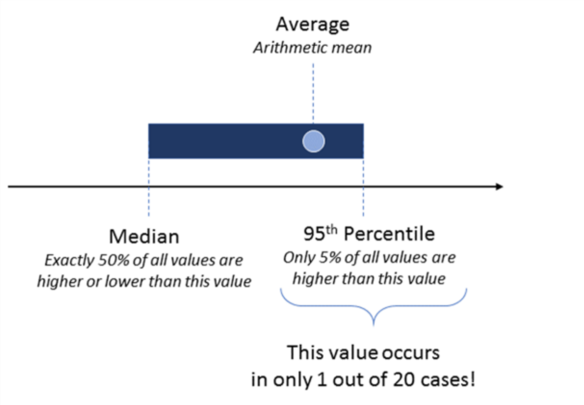
5 Detailed results of each modelling tool

Bar charts in this section show the probabilistic range of the adequacy index LLD for both the 2021 and 2025 Base-Case scenarios. They consist of the 50th and 95th percentiles of the distributions of the simulation results (or, in other words, the results for the risk of 1 in 2 years to 1 in 20 years). Moreover, average values of adequacy indices (LOLE or EENS) of all simulated climatic years are represented as dots for all simulation tools. Figure 16 below illustrates how the results are presented in this section.

How to read the results

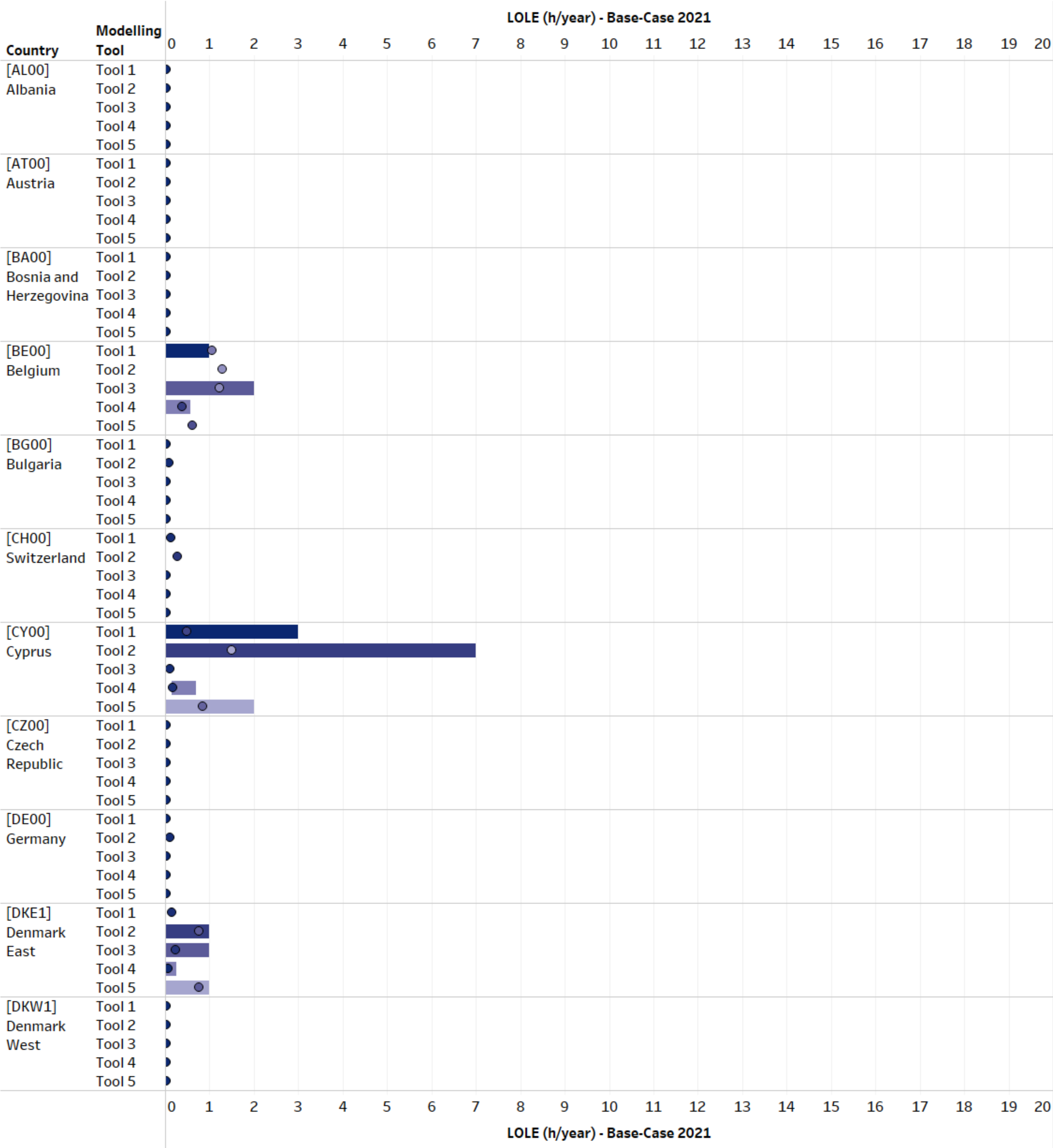


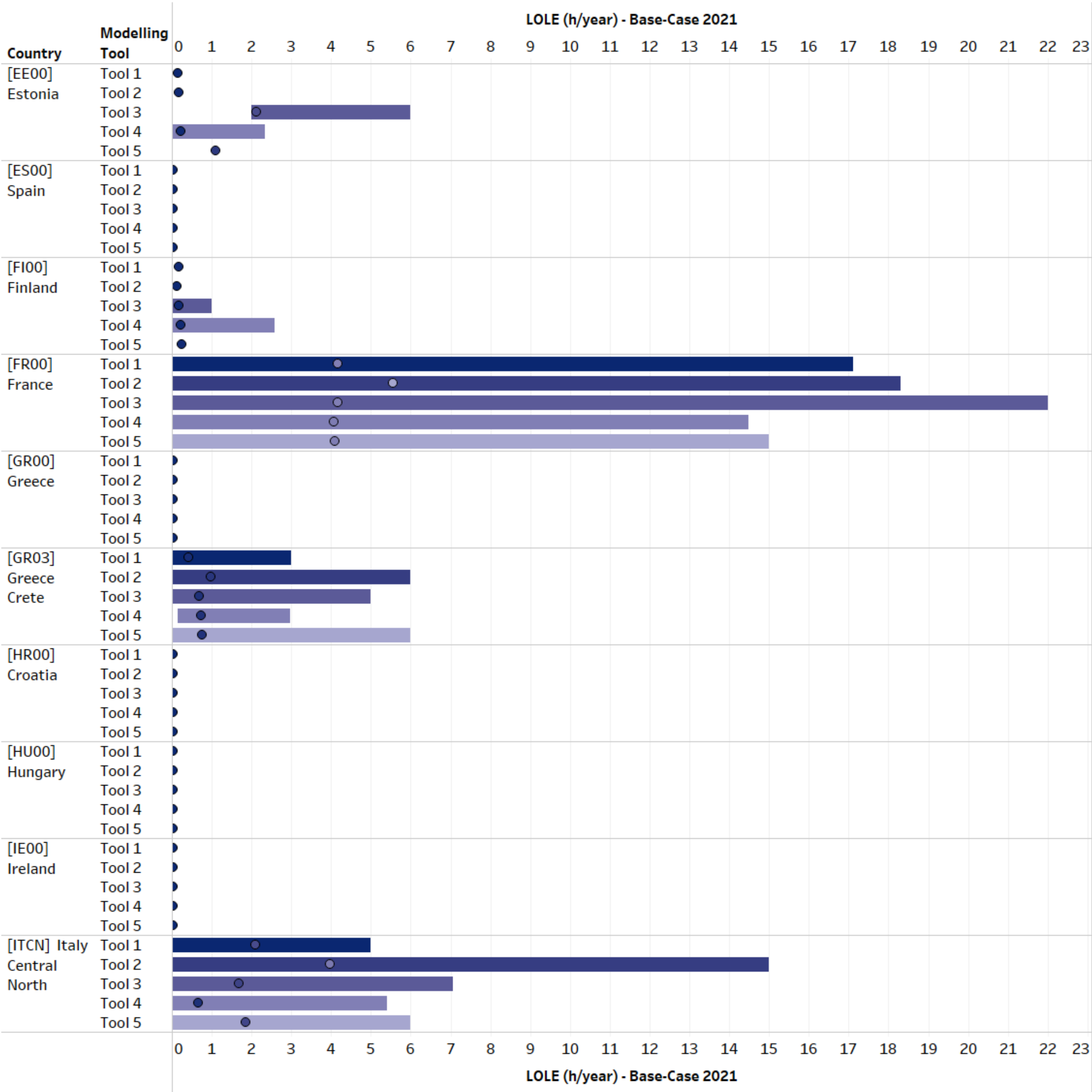
Example:
A market modelling tool calculates the LLD for 100 Monte Carlo years. The 95th percentile (often abbreviated as P95) of the results' distribution is the 5th highest value observed, corresponding to a probability of '1 in 20'.

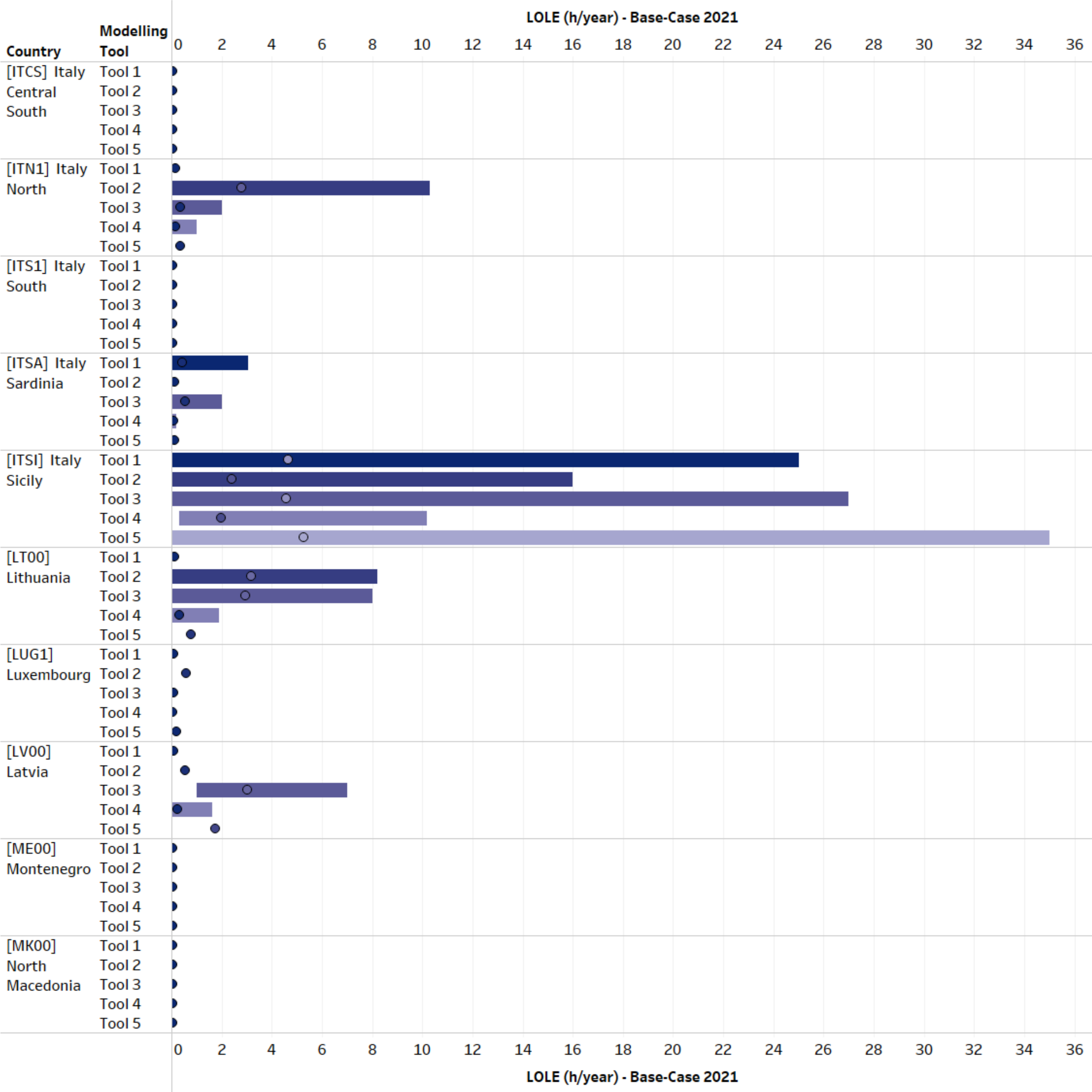
Figure 16: How to read the detailed MAF results

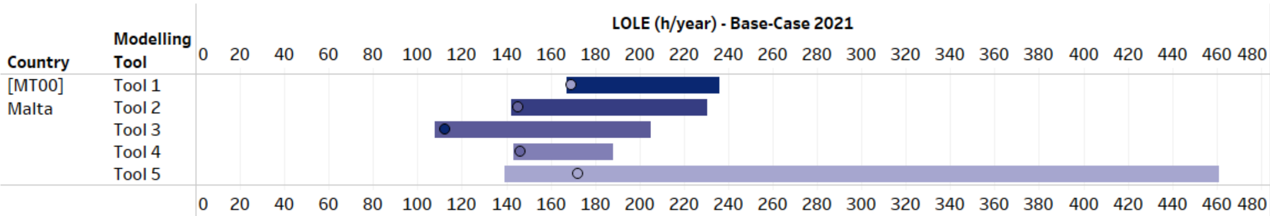
5.1 Adequacy results for 2021

Figure 17 – LOLE (h/year) results by tool for Base-Case 2021 (part 1)




LOLE (h/year) - Base-Case 2021
Country
Modelling Tool
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
[EE00] Estonia
[ES00] Spain
[FI00] Finland
[FR00] France
[GR00] Greece
[GR03] Greece Crete
[HR00] Croatia
[HU00] Hungary
[IE00] Ireland
[ITCN] Italy Central North
Tool 1
Tool 2
Tool 3
Tool 4
Tool 5





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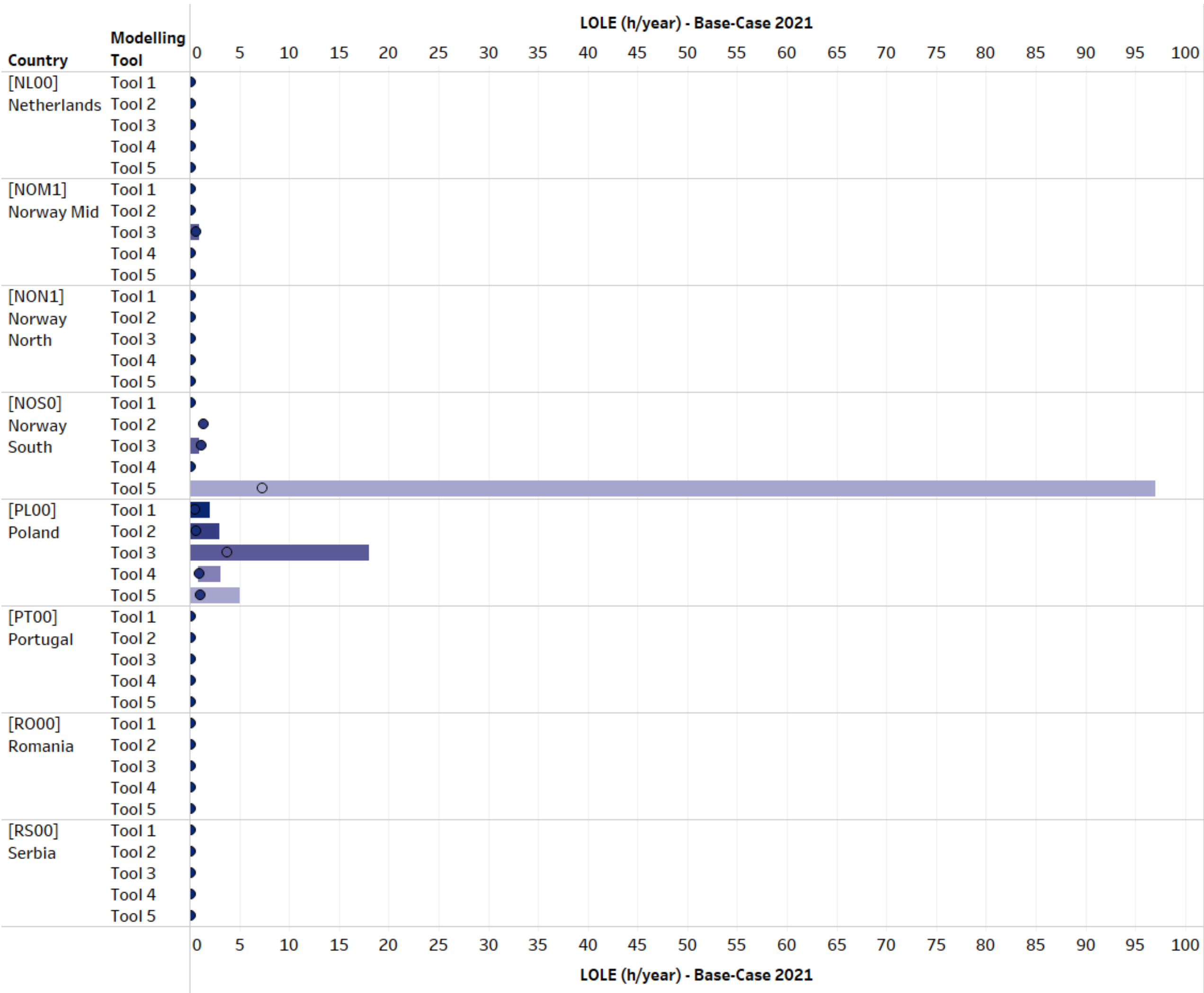
LOLE (h/year) - Base-Case 2021
Country
Modelling Tool
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
[NL00] Netherlands
[NOM1] Norway Mid
[NON1] Norway North
[NOS0] Norway South
[PL00] Poland
[PT00] Portugal
[RO00] Romania
[RS00] Serbia
Tool 1
Tool 2
Tool 3
Tool 4
Tool 5

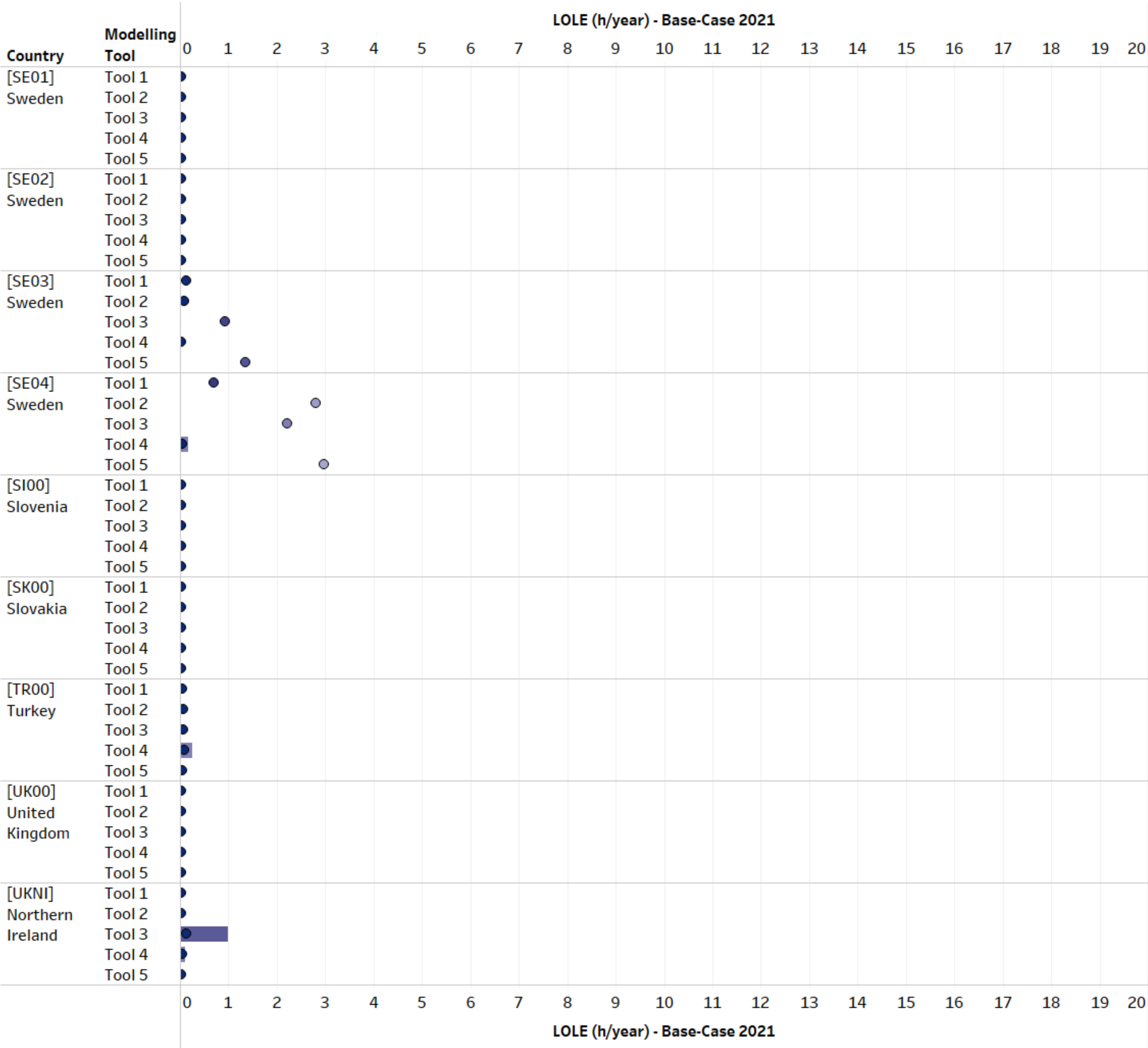

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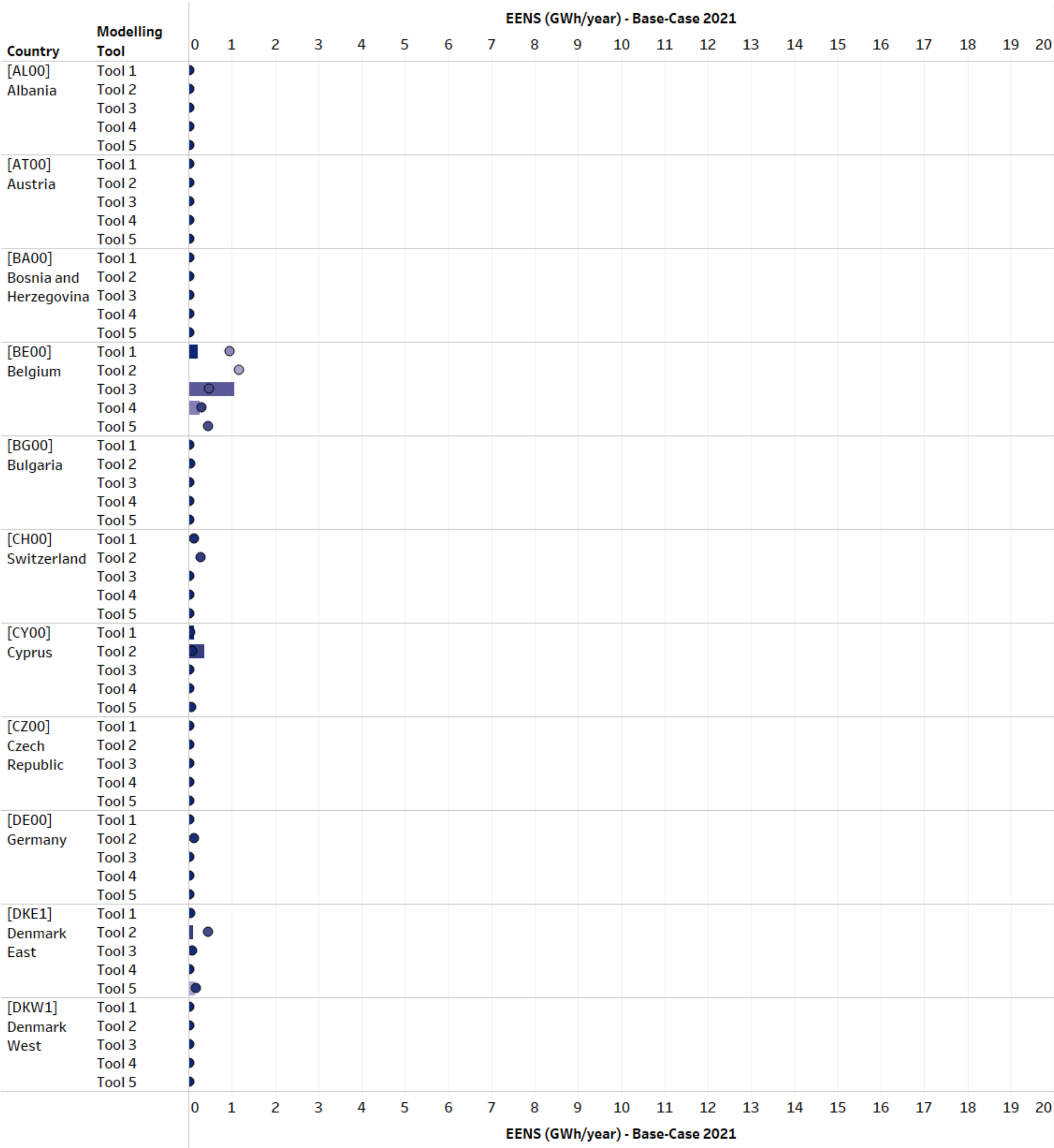
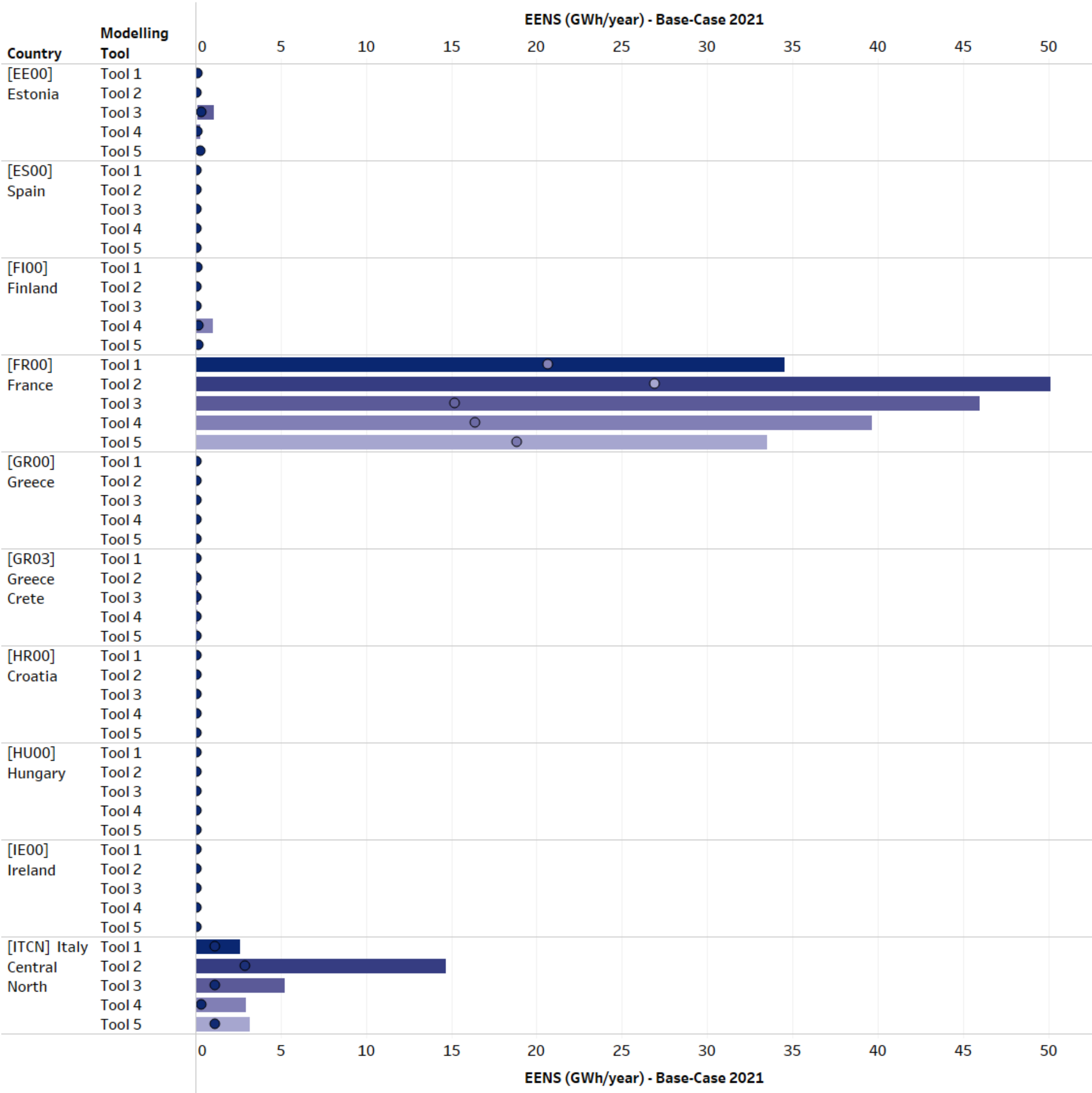
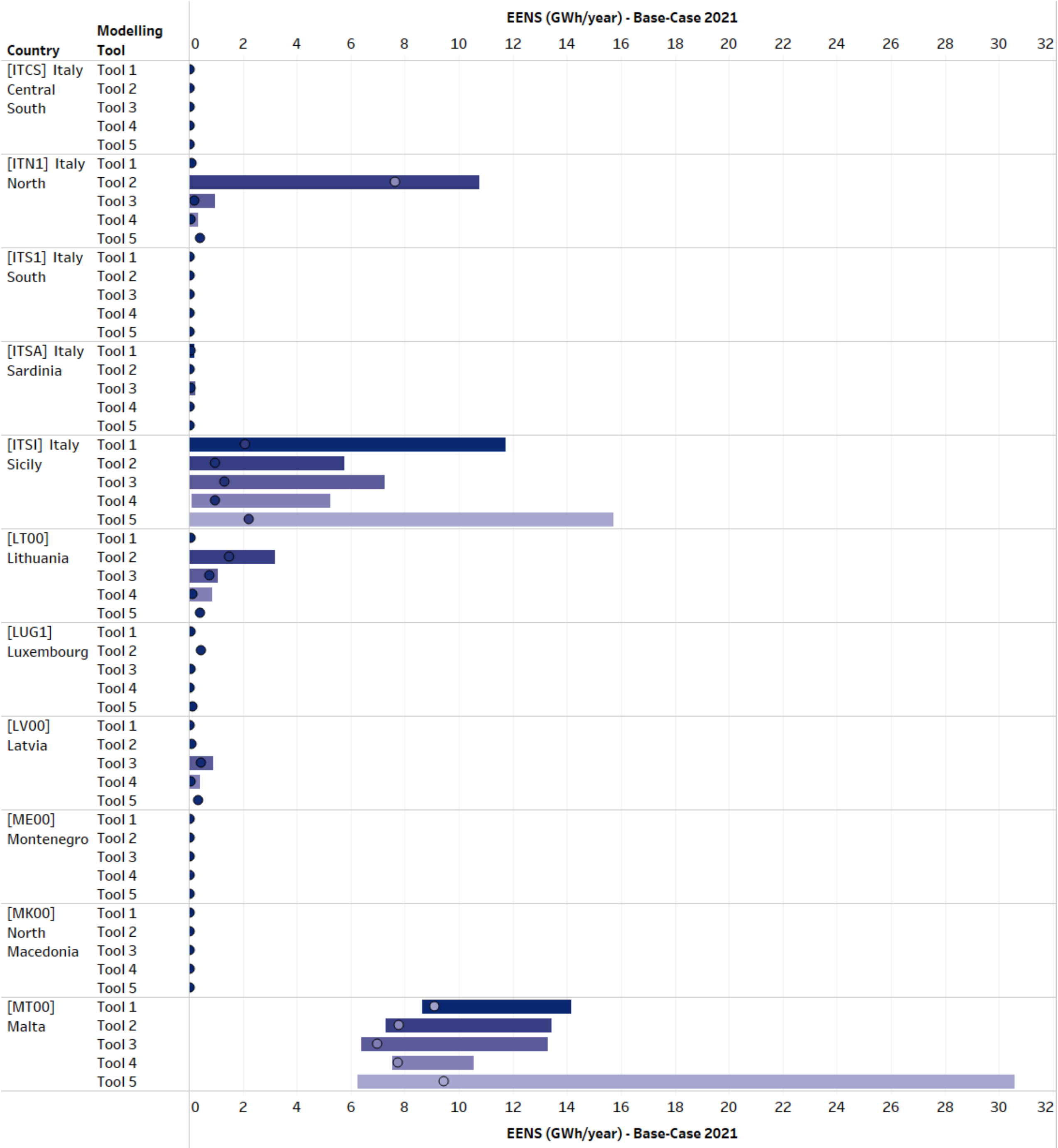
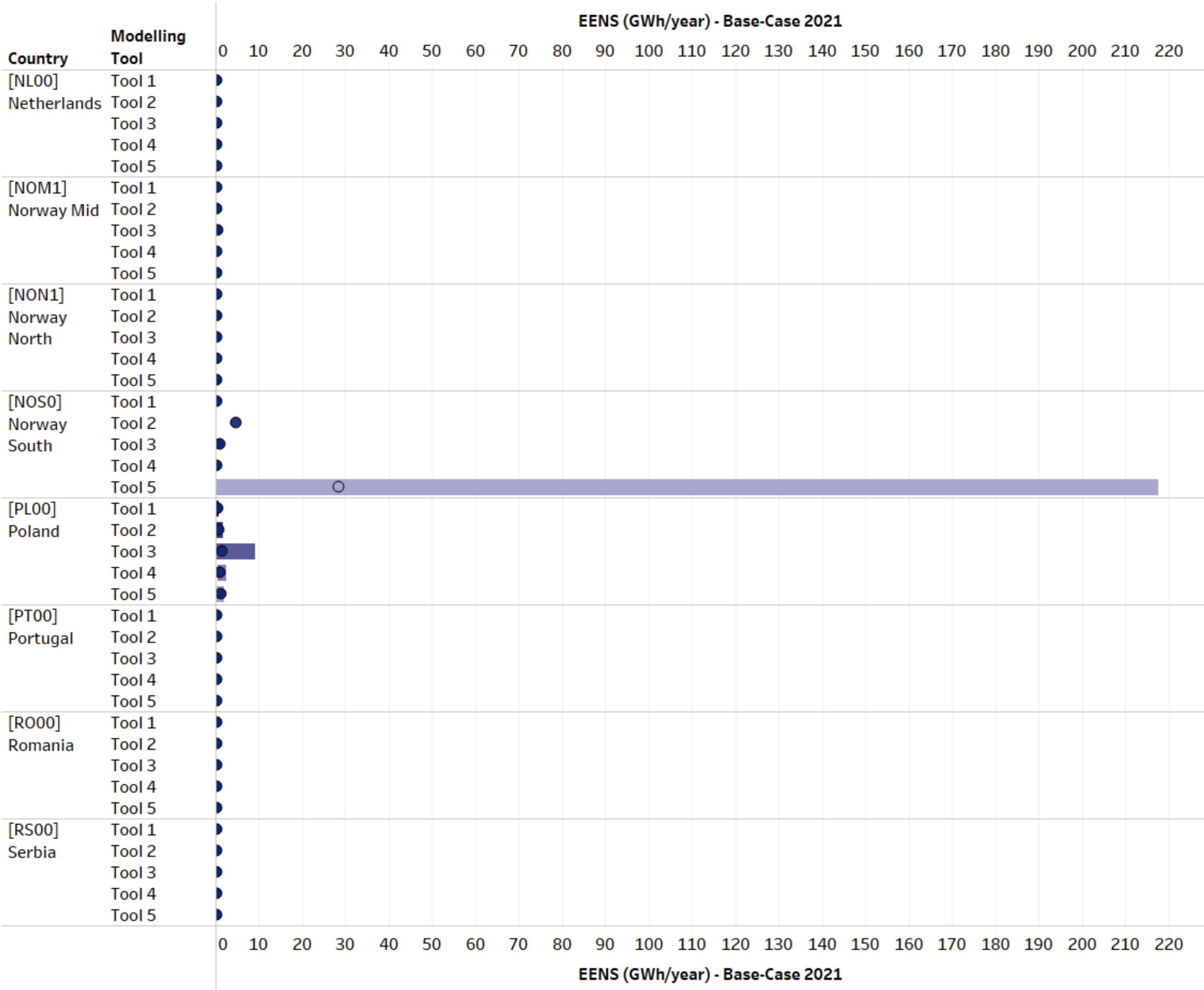
Figure 18: EENS (GWh) results by tool for Base-Case 2021




EENS (GWh/year) - Base-Case 2021
Country
Modelling Tool
0 5 10 15 20 25 30 35 40 45 50
[EE00] Estonia
[ES00] Spain
[FI00] Finland
[FR00] France
[GR00] Greece
[GR03] Greece Crete
[HR00] Croatia
[HU00] Hungary
[IE00] Ireland
[ITCN] Italy Central North
Tool 1
Tool 2
Tool 3
Tool 4
Tool 5



EENS (GWh/year) - Base-Case 2021
Country
Modelling Tool
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32
[ITCS] Italy Central South
[ITN1] Italy North
[ITS1] Italy South
[ITSA] Italy Sardinia
[ITSI] Italy Sicily
[LT00] Lithuania
[LUG1] Luxembourg
[LV00] Latvia
[ME00] Montenegro
[MK00] North Macedonia
[MT00] Malta
Tool 1
Tool 2
Tool 3
Tool 4
Tool 5



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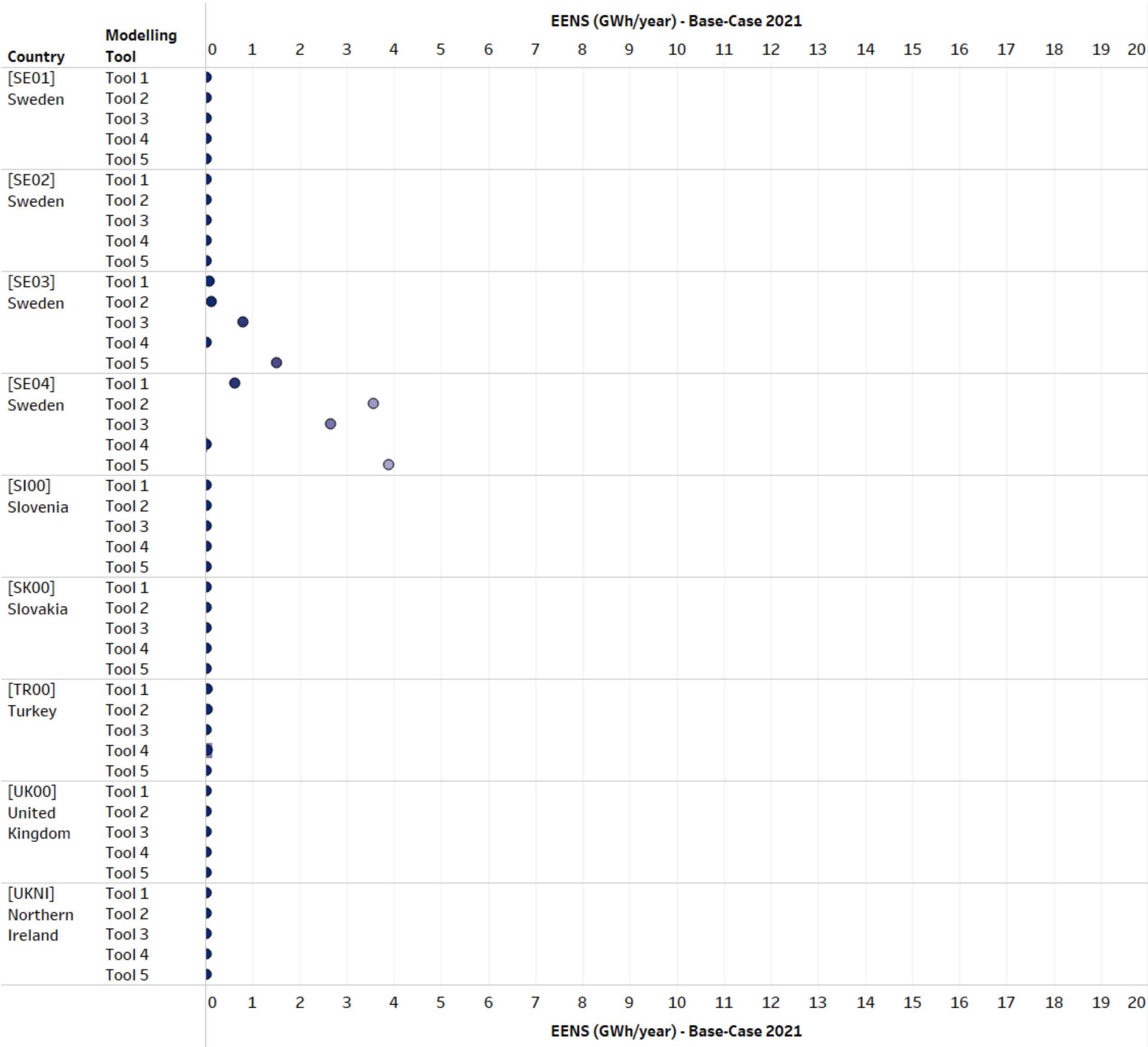
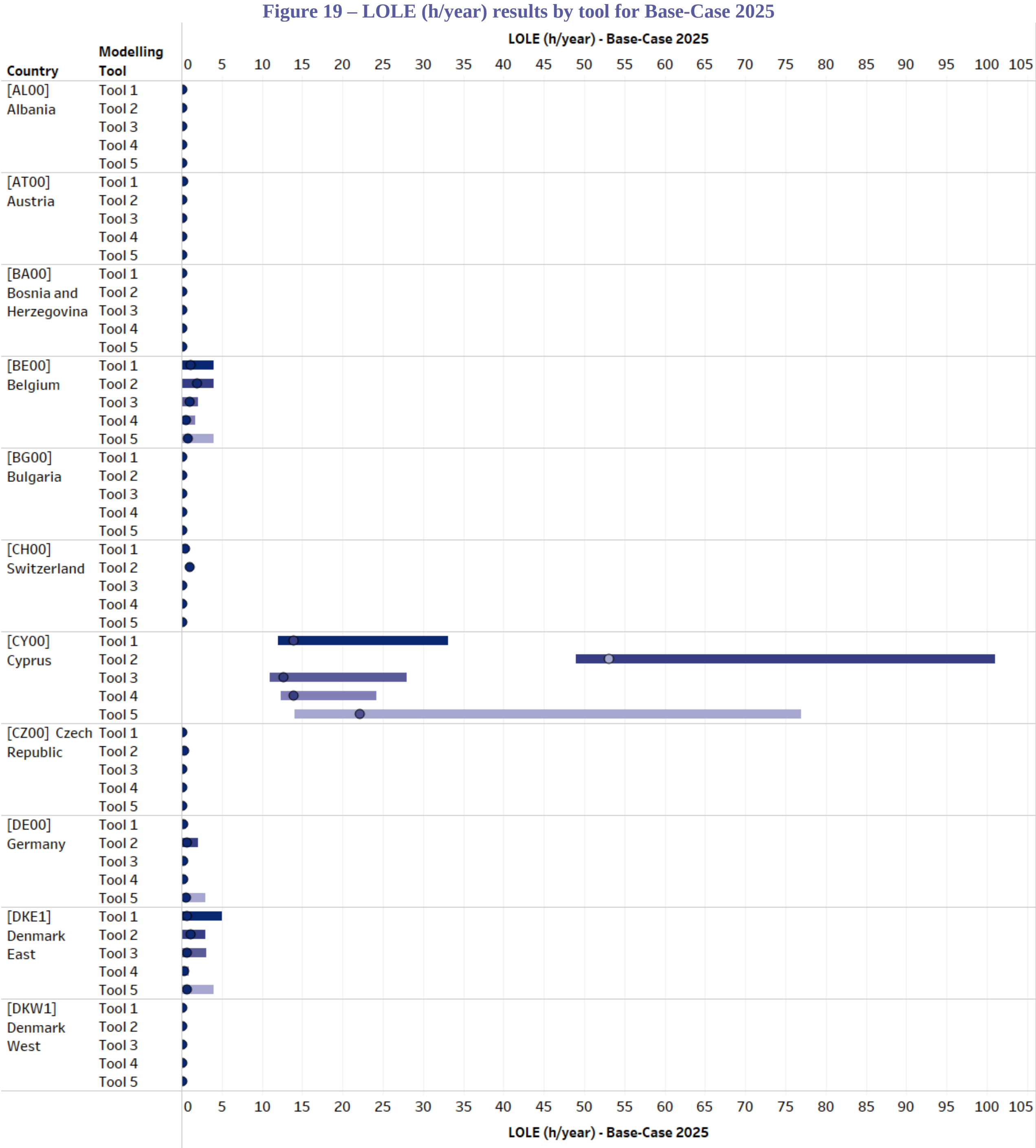

EENS (GWh/year) - Base-Case 2021
Country
Modelling Tool
[SE01] Sweden
[SE02] Sweden
[SE03] Sweden
[SE04] Sweden
[SI00] Slovenia
[SK00] Slovakia
[TR00] Turkey
[UK00] United Kingdom
[UKNI] Northern Ireland
Tool 1
Tool 2
Tool 3
Tool 4
Tool 5
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

5.2 Adequacy results for 2025

Figure 19 – LOLE (h/year) results by tool for Base-Case 2025



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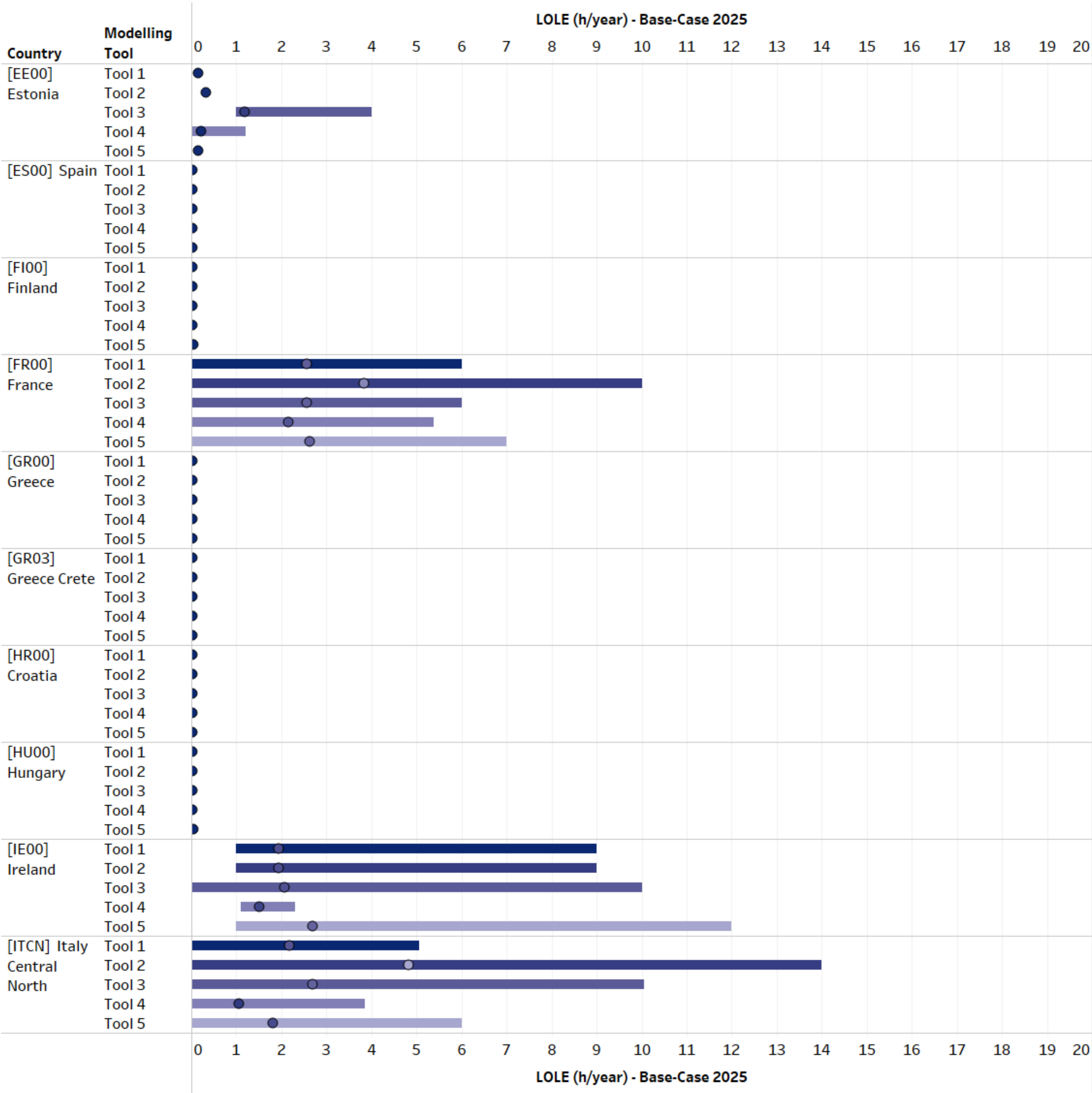
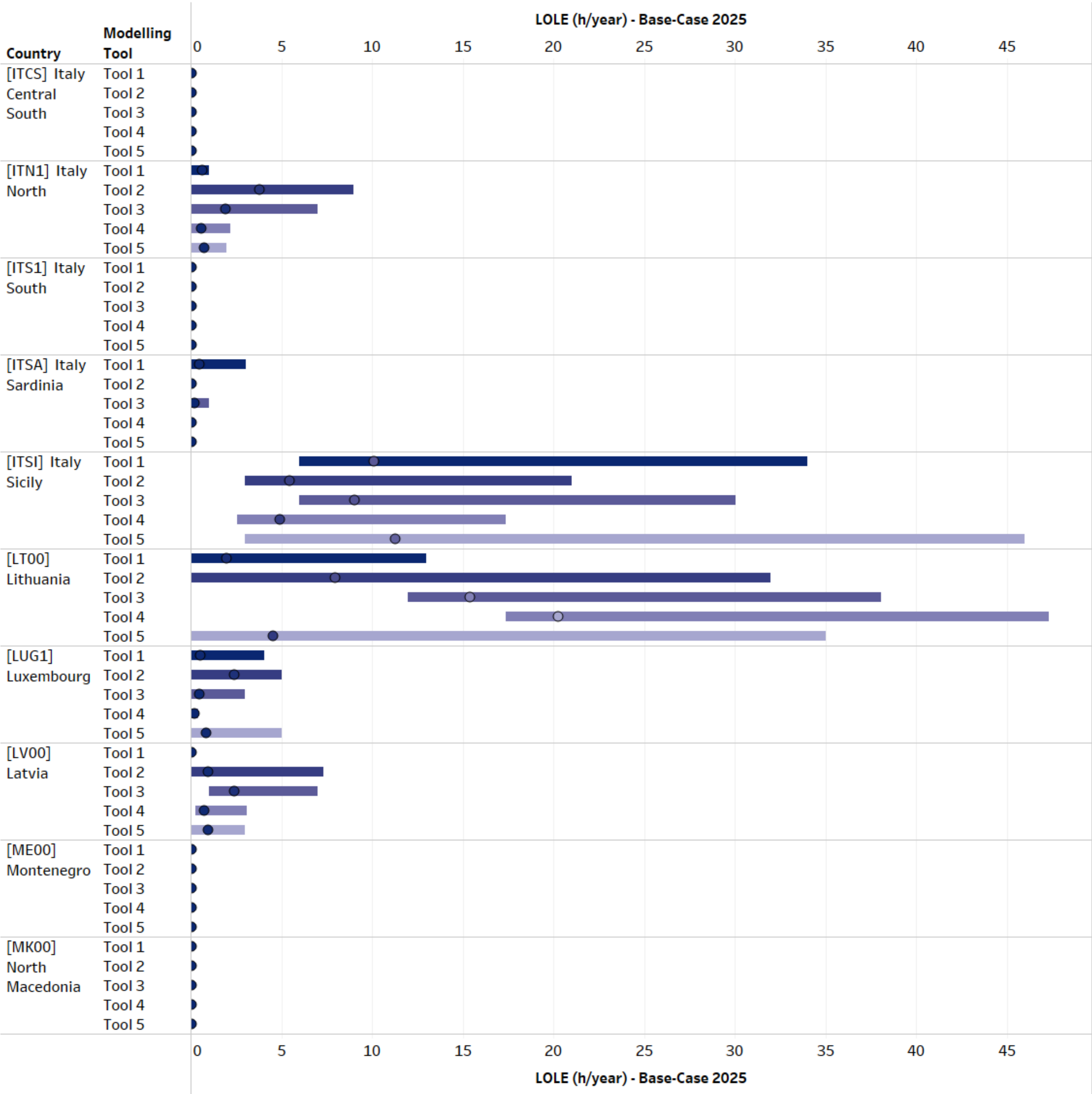
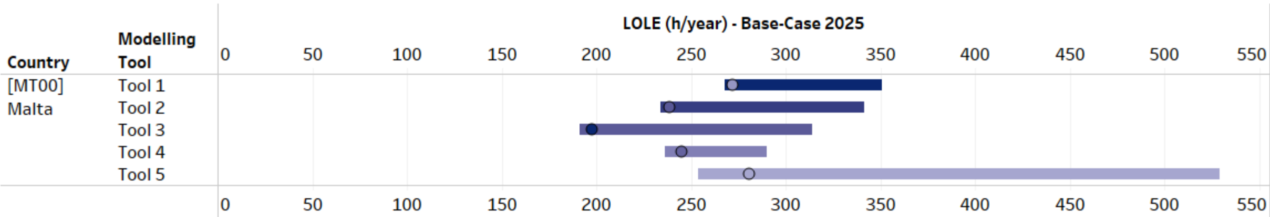
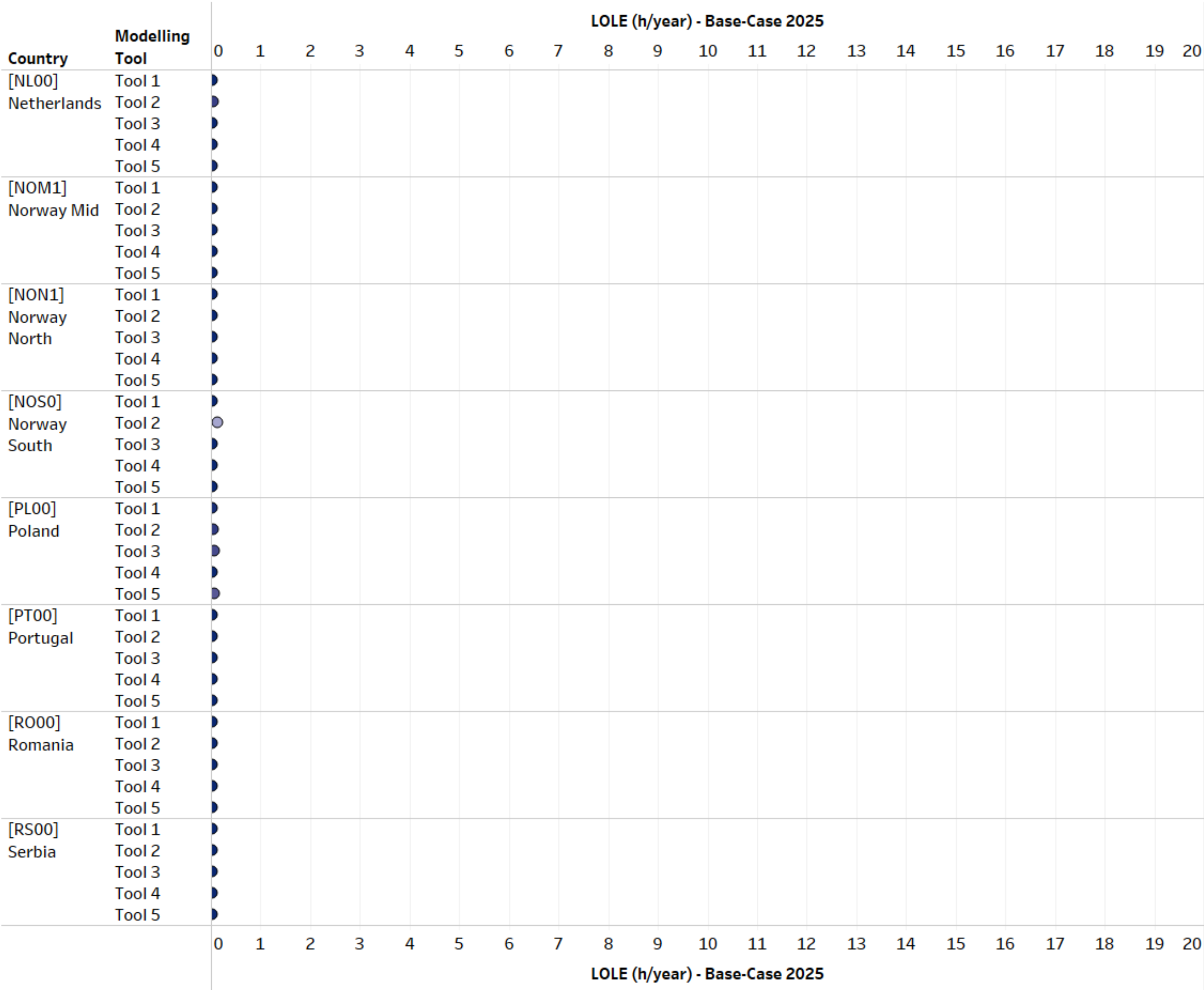

LOLE (h/year) - Base-Case 2025
Country
Modelling Tool
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
[EE00] Estonia
[ES00] Spain
[FI00] Finland
[FR00] France
[GR00] Greece
[GR03] Greece Crete
[HR00] Croatia
[HU00] Hungary
[IE00] Ireland
[ITCN] Italy Central North
Tool 1
Tool 2
Tool 3
Tool 4
Tool 5


LOLE (h/year) - Base-Case 2025
Country
Modelling Tool
0 5 10 15 20 25 30 35 40 45
[ITCS] Italy Central South
[ITN1] Italy North
[ITS1] Italy South
[ITSA] Italy Sardinia
[ITSI] Italy Sicily
[LT00] Lithuania
[LUG1] Luxembourg
[LV00] Latvia
[ME00] Montenegro
[MK00] North Macedonia
Tool 1
Tool 2
Tool 3
Tool 4
Tool 5


LOLE (h/year) - Base-Case 2025
Country
Modelling Tool
0 50 100 150 200 250 300 350 400 450 500 550
[MT00] Malta
Tool 1
Tool 2
Tool 3
Tool 4
Tool 5


LOLE (h/year) - Base-Case 2025
Country
Modelling Tool
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
[NL00] Netherlands
[NOM1] Norway Mid
[NON1] Norway North
[NOS0] Norway South
[PL00] Poland
[PT00] Portugal
[RO00] Romania
[RS00] Serbia
Tool 1
Tool 2
Tool 3
Tool 4
Tool 5

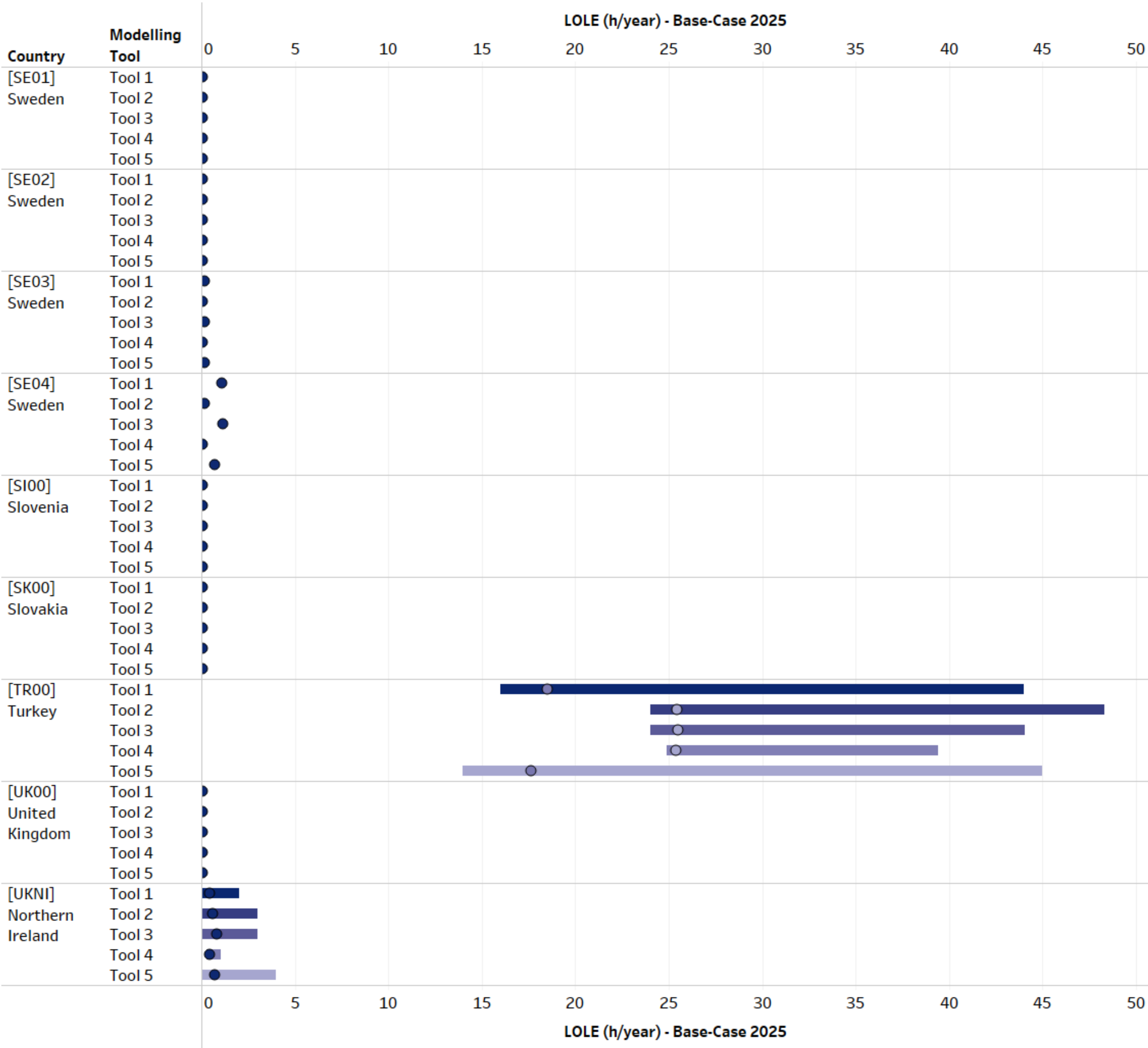
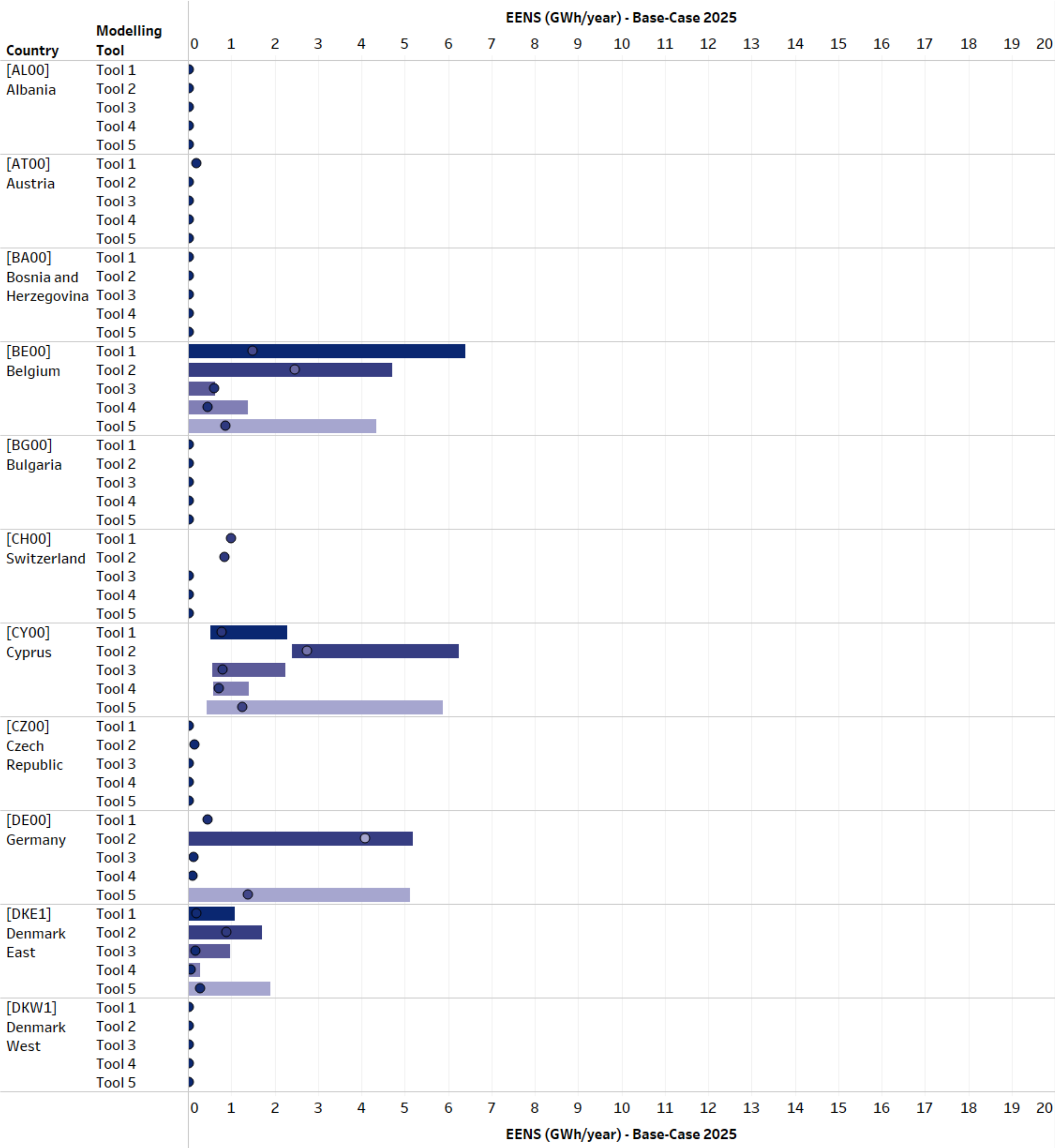
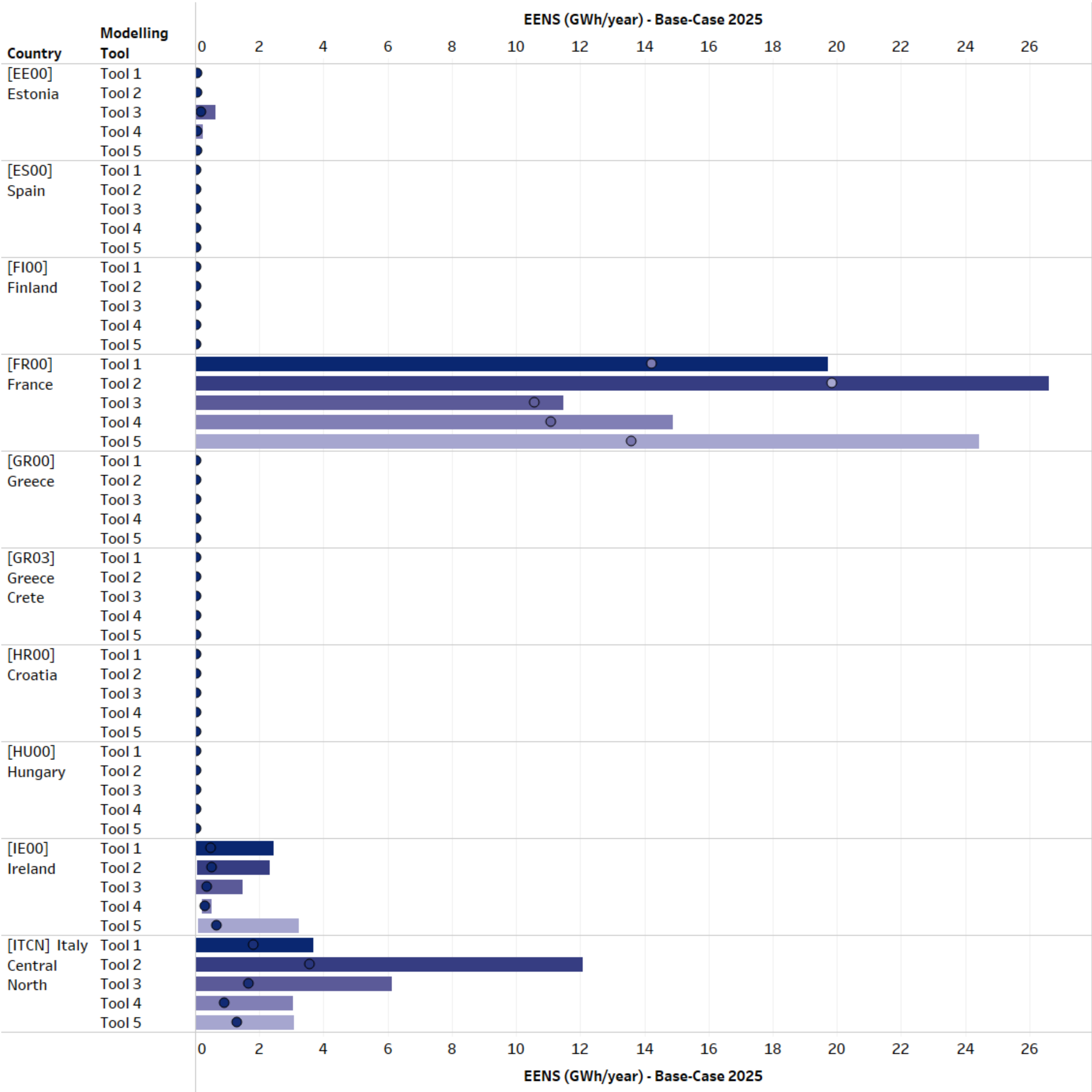
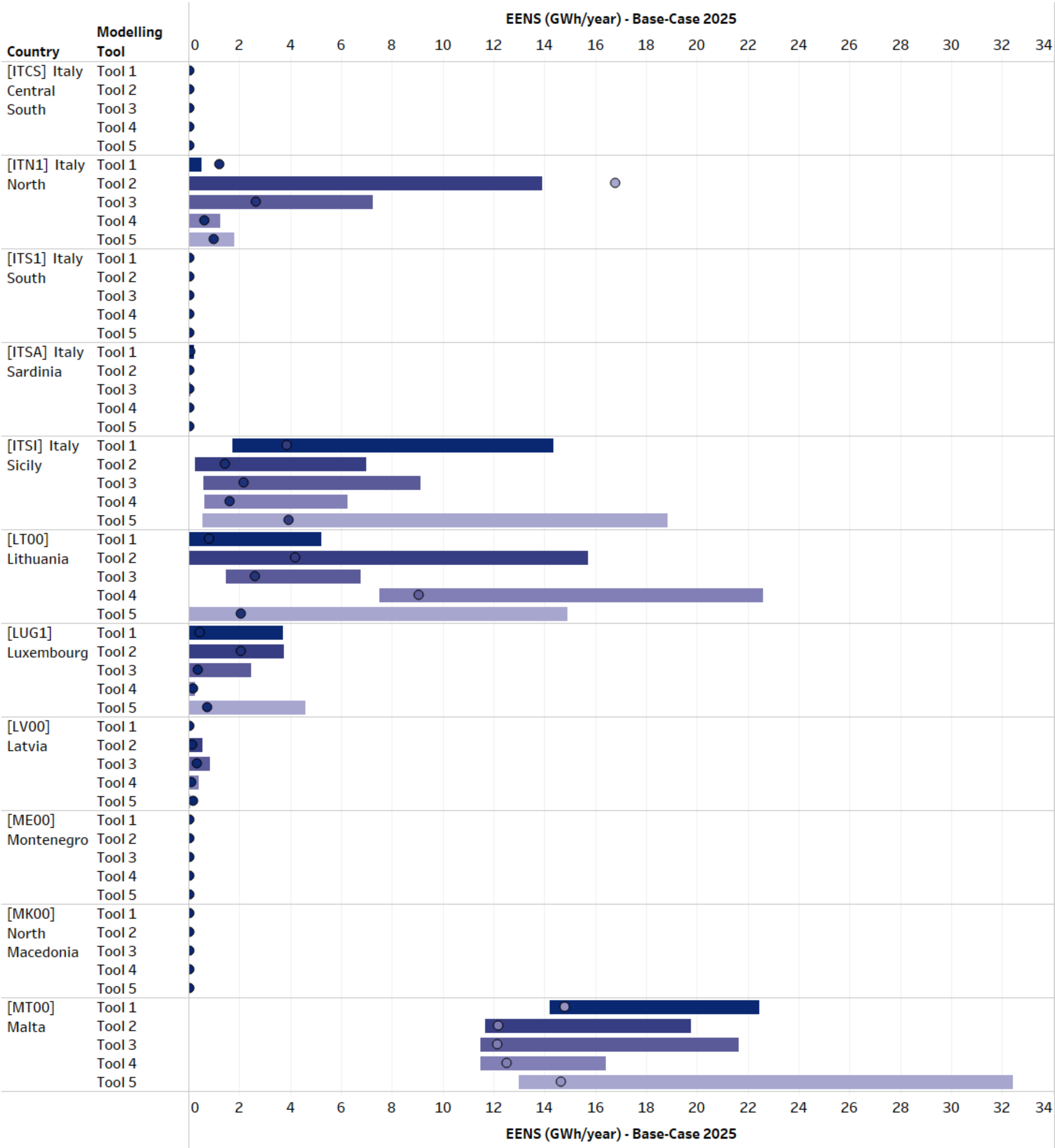
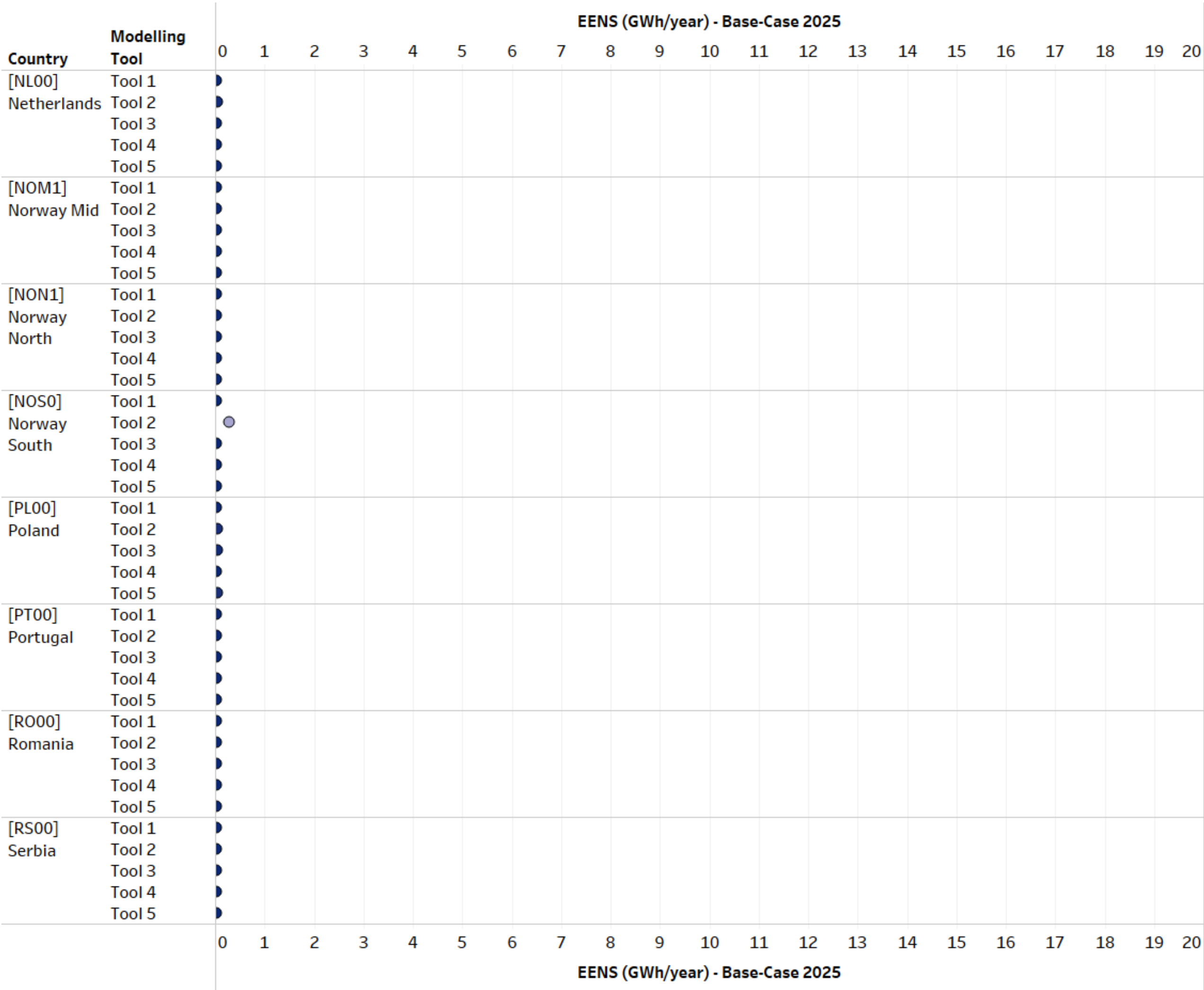

LOLE (h/year) - Base-Case 2025
Country
Modelling Tool
0 5 10 15 20 25 30 35 40 45 50
[SE01] Sweden
[SE02] Sweden
[SE03] Sweden
[SE04] Sweden
[SI00] Slovenia
[SK00] Slovakia
[TR00] Turkey
[UK00] United Kingdom
[UKNI] Northern Ireland
Tool 1
Tool 2
Tool 3
Tool 4
Tool 5

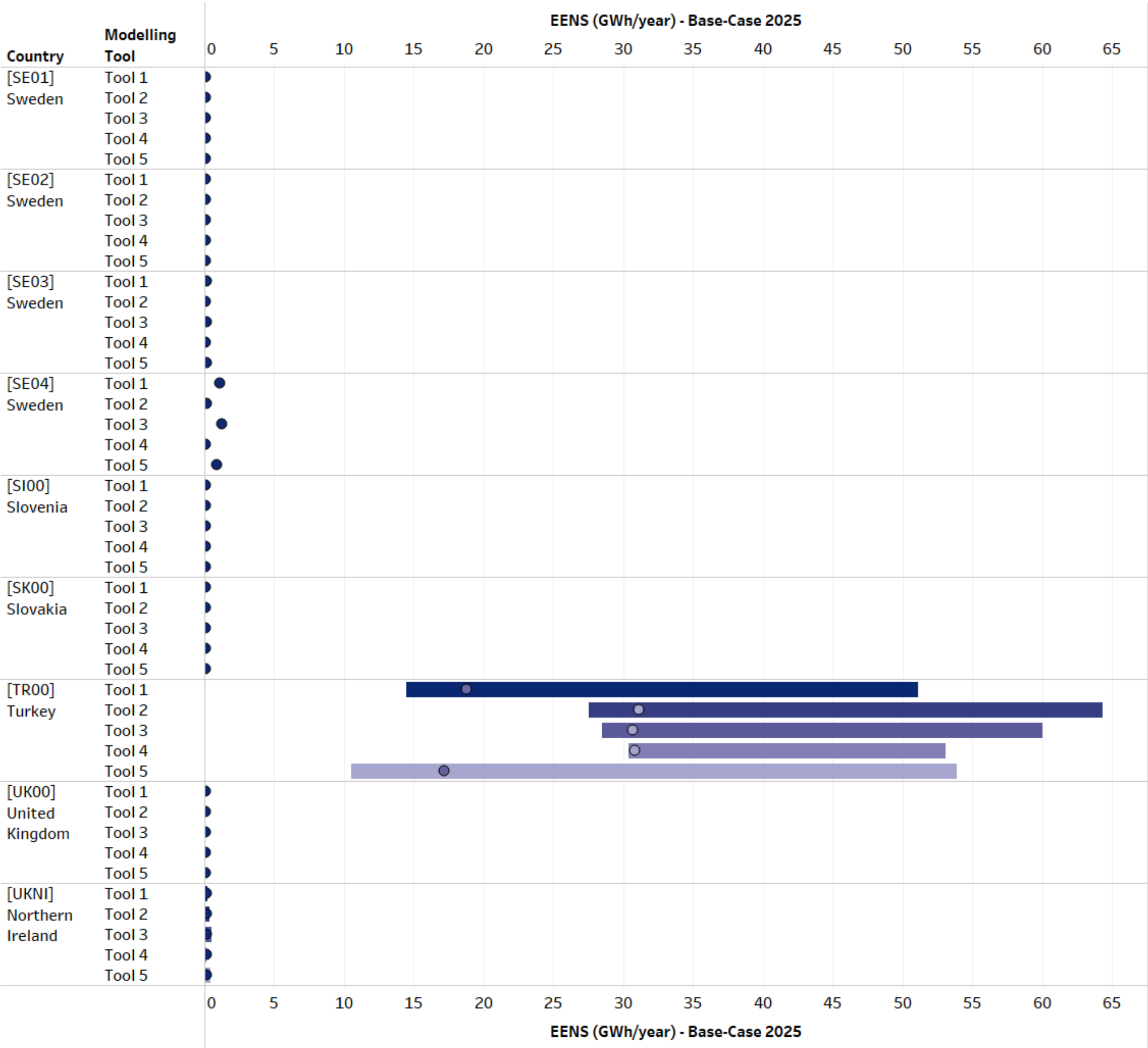
Figure 20: EENS (GWh) results by tool for Base-Case 2025




EENS (GWh/year) - Base-Case 2025
Country
Modelling Tool
0 2 4 6 8 10 12 14 16 18 20 22 24 26
[EE00] Estonia
[ES00] Spain
[FI00] Finland
[FR00] France
[GR00] Greece
[GR03] Greece Crete
[HR00] Croatia
[HU00] Hungary
[IE00] Ireland
[ITCN] Italy Central North
Tool 1
Tool 2
Tool 3
Tool 4
Tool 5


EENS (GWh/year) - Base-Case 2025
Country
Modelling Tool
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34
[ITCS] Italy Central South
[ITN1] Italy North
[ITS1] Italy South
[ITSA] Italy Sardinia
[ITSI] Italy Sicily
[LT00] Lithuania
[LUG1] Luxembourg
[LV00] Latvia
[ME00] Montenegro
[MK00] North Macedonia
[MT00] Malta
Tool 1
Tool 2
Tool 3
Tool 4
Tool 5


EENS (GWh/year) - Base-Case 2025
Country
Modelling Tool
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
[NL00] Netherlands
[NOM1] Norway Mid
[NON1] Norway North
[NOS0] Norway South
[PL00] Poland
[PT00] Portugal
[RO00] Romania
[RS00] Serbia
Tool 1
Tool 2
Tool 3
Tool 4
Tool 5



EENS (GWh/year) - Base-Case 2025
Country
Modelling Tool
0 5 10 15 20 25 30 35 40 45 50 55 60 65
[SE01] Sweden
[SE02] Sweden
[SE03] Sweden
[SE04] Sweden
[SI00] Slovenia
[SK00] Slovakia
[TR00] Turkey
[UK00] United Kingdom
[UKNI] Northern Ireland
Tool 1
Tool 2
Tool 3
Tool 4
Tool 5