November 2023

Med-TSO

TeasiMed2 project

Winter Outlook 2023/2024

Mediterranean Adequacy Assessments

Co-funded by the European Union

www.med-tso.org

Purpose of the Winter Outlook 2023/2024

This brochure presents the adequacy results from among non-EU Med-TSO members with a view to this winter (2023/2024), the conclusions of this assessment show that during this winter the most severe adequacy issues may occur in Lebanon.

With this assessment, Med-TSO aligns with global best practices and the latest development of the EU regulations[1]. In general, these investigations ascertain whether available resources are sufficient to cover required electricity demand while complying with transmission grid operational security limits.

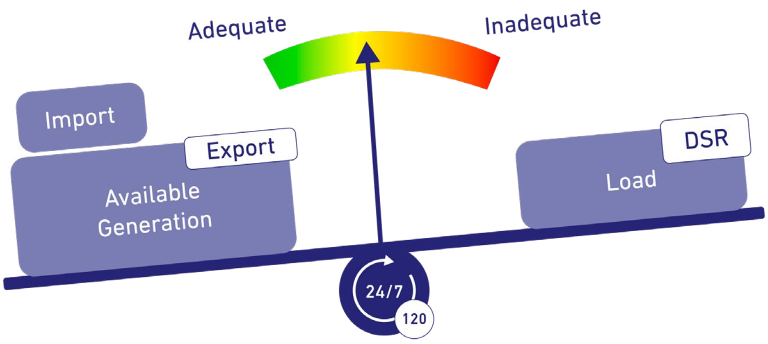

Figure 1 | Balance between net available generation and net load (source: ERAA 2021)

These investigations evaluate the security of electricity supply to consumers by conducting a comprehensive examination of power system adequacy using probabilistic criteria. This approach is indispensable due to the unpredictable nature of renewable energy systems (RES), their intermittency and the dynamics of power system operation. which raise the question of power system adequacy in the short, mid, and long term. Moreover, the integration of immense amounts of RES must be closely followed by the commissioning of devices that can provide adequate power system flexibility.

Given the changes occurring in the electricity sector in countries around the Mediterranean Sea – from energy market development, to integration of renewable energy sources and efforts to decarbonise energy systems – adequacy monitoring has become increasingly important.

The Winter Outlook 2023/2024 report provides information about potential adequacy issues during winter 2023/2024 in seven MED-TSO member states: Morocco, Algeria, Tunisia, Libya, Egypt, Jordan and Lebanon[2].

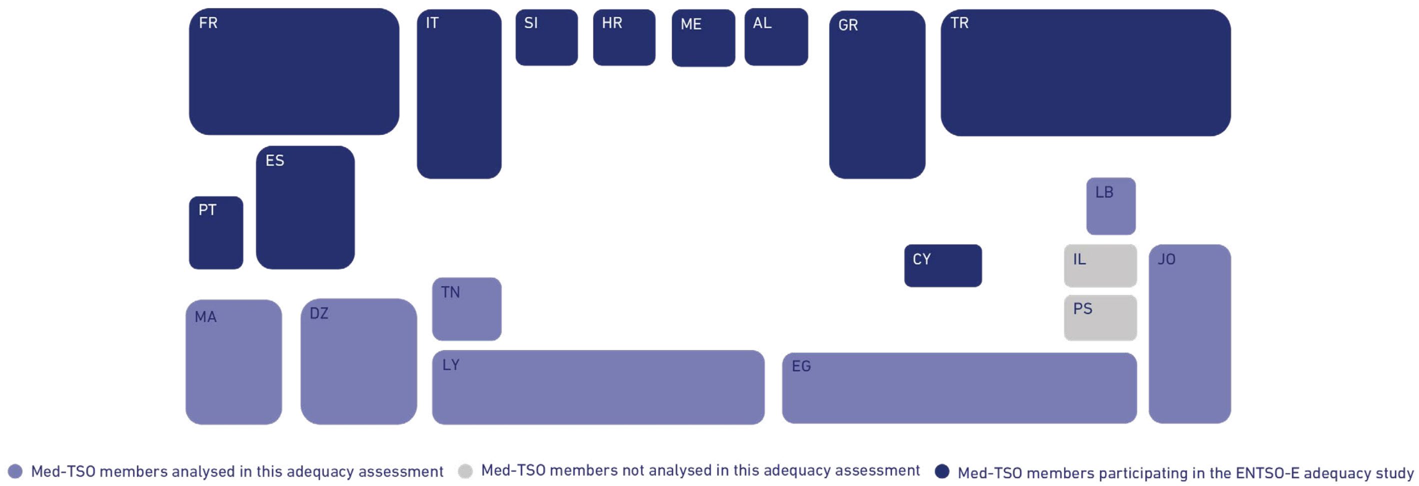

Figure 2 | Med-TSO members and neighboring countries (source: Med-TSO)

The period analysed includes all hours between the beginning of week 48 and the end of week 52 in 2023 (with the exception of December 31st) and all hours between the beginning of week 1 and the end of week 13 in 2024.

1 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019R0943&from=en

2 Data for Israel and Palestine are not available at the present time.

Approach and methodology used In Winter Outlook 2023/2024

As a general approach, a probabilistic Monte Carlo simulation with a Unit Commitment and Economic Dispatch (UCED) model has been employed, ensuring inter-zonal and inter-temporal correlation of variables while considering the specificities of the assessed geographical perimeter. The hourly resolution has been implemented into the model and the Monte Carlo approach has been used to reflect the variability of weather as well as the randomness of supply and transmission outages.

Multiple Monte Carlo (MC) years were generated to assess adequacy risks under different conditions for the analysed timeframe (Figure 3). For all MC years, hourly calculations were performed for the whole geographical scope. The analyses have been conducted with the ANTARES simulator (Figure 4).

Figure 3 | Probabilistic modelling general approach (source: ENTSO-E)

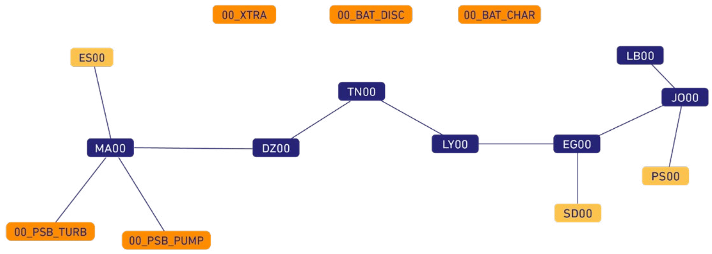

Figure 4 | Illustrative Example of Antares Model diagram

The seasonal adequacy assessment is based on the following main indicators:

- **P95/P50 LOLD/ENS:** P95/P50 Loss of Load Duration or Energy Not Supplied (Figure 5).
  While LOLD in a given geographical zone for a given period is the number of hours during which the zone experiences, ENS during a single Monte Carlo sample/simulation year, P95/P50 LOLD are LOLD in more or less severe operational conditions:
  - P95: LOLD/ENS that happens once in 20 years.
  - P50: LOLD/ENS that happens once in 2 years.
- **Loss of Load Expectation** (LOLE) or **Expected Energy Not Supplied** (EENS) in a given geographical zone for a given period is the expected number of hours per year when there would be a lack of resources to cover the demand needs, within a sufficient transmission grid operational security limit or corresponding expected value of energy not to be supplied.
- **Dump Energy** or **RES curtailment**, in a given geographical zone for a given period, is the energy generated in excess that cannot be balanced, for instance when the load is low and the in-feed from renewable is high.
- The **Capacity Margin** for a given geographical zone for a given point in time is the difference between the available and engaged TPP capacity, as presented in the following diagram (Figure 6). These values indicate excess of capacity in the system.

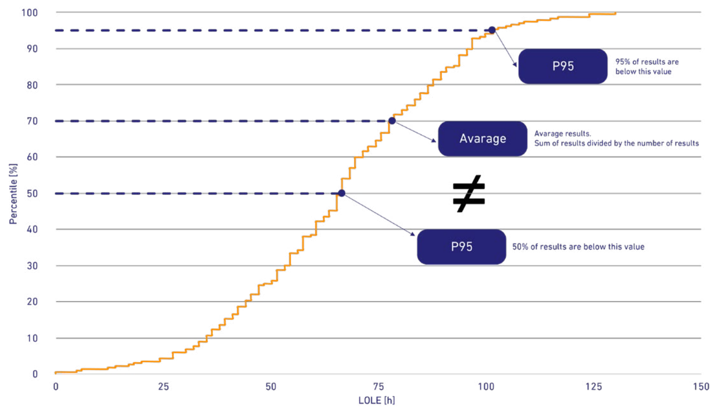

Figure 5 | Illustrative Example of the relation between average, P50 and P95 values

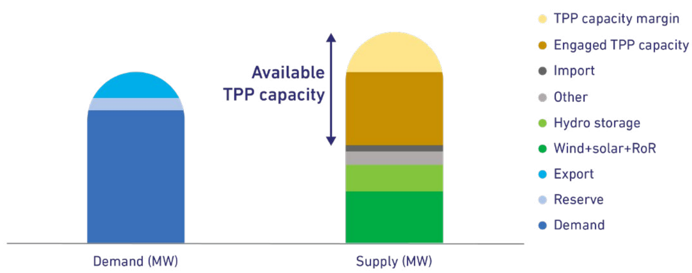

Figure 6 | Illustrative Example of TPP capacity margin identification

Main findings of the Winter Outlook 2023/2024

For probabilistic simulations, a total of 684 MC years have been constructed by combining climate-dependent variables (wind, solar and demand from 38 climatic years), available hydro power time series and given/random outages:

- Climate years (each of 38 years from the period 1982-2019) were selected individually.
- Each climate year was associated with random outage samples, i.e., randomly assigned unplanned outage patterns for thermal units.

The adequacy situation was assessed using a two-step approach:

- In the first step, adequacy under isolated system operation was evaluated.

Figure 7 | Seasonal Relative EENS and LOLE for the isolated mode of operation for only winter season

- In the second, adequacy under interconnected system operation was assessed to quantify the importance of Med-TSO interconnections.

Figure 8 | Seasonal Relative EENS and LOLE for the interconnected mode of operation for only winter season

In the case of a theoretical isolated scenario, adequacy risks can be observed in some countries such as Lebanon, Jordan, Libya and Morocco, although they could be considered as small or marginal in the case of Jordan end Libya, and medium risk in the case of Morocco. In the case of Lebanon alone, the adequacy risk is very high under an isolated system operating mode.

Interconnections and energy exchanges with neighbouring countries reduce adequacy risks to close to zero in Morocco, Libya end Jordan, but, in Lebanon, even in this more relaxed operating mode, adequacy risks remain at an unacceptable level.

The following tables present ENS and LOLD seasonal results are given for all analysed countries.

	Isolated EENS	Interconnected EENS
DZ	0 MWH	0 MWH
	50th percentile ENS 0 MWh	50th percentile ENS 0 MWh
	95th percentile ENS 0 MWh	95th percentile ENS 0 MWh
EG	0 MWH	0 MWH
	50th percentile ENS 0 MWh	50th percentile ENS 0 MWh
	95th percentile ENS 0 MWh	95th percentile ENS 0 MWh
JO	120 MWH	10 MWH
	50th percentile ENS 0 MWh	50th percentile ENS 0 MWh
	95th percentile ENS 746 MWh	95th percentile ENS 22 MWh
MA	5051 MWH	0 MWH
	50th percentile ENS 0 MWh	50th percentile ENS 0 MWh
	95th percentile ENS 29692 MWh	95th percentile ENS 0 MWh
TN	1 MWH	0 MWH
	50th percentile ENS 0 MWh	50th percentile ENS 0 MWh
	95th percentile ENS 0 MWh	95th percentile ENS 0 MWh
LY	637 MWH	144 MWH
	50th percentile ENS 0 MWh	50th percentile ENS 0 MWh
	95th percentile ENS 5340 MWh	95th percentile ENS 983 MWh
LB	1165431 MWH	697384 MWH
	50th percentile ENS 1139414 MWh	50th percentile ENS 668969 MWh
	95th percentile ENS 1639986 MWh	95th percentile ENS 1103222 MWh

Isolated EENS	Interconnected EENS
0 MWH	0 MWH
50th percentile ENS 0 MWh	50th percentile ENS 0 MWh
95th percentile ENS 0 MWh	95th percentile ENS 0 MWh
0 MWH	0 MWH
50th percentile ENS 0 MWh	50th percentile ENS 0 MWh
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Importance of Interconnection

We have explored the interconnections between the countries under analysis and their need for energy exchange to mitigate the anticipated adequacy challenges in the upcoming winter. Our primary objective was to evaluate potential cross-border exchanges among the seven analysed nations and quantify each country's requirements to address adequacy risks during periods of isolation.
The following table summarises the feasible exchanges and NTC among the countries subject to our analysis.
Interconnections improve the adequacy situation in some countries but present the indispensable support to adequacy that will be needed in Lebanon and Libya.

Link	Direct Exchanges and Adequacy (GWh)	NTC direct (MW)	Reverse Exchange for Adequacy (GWh)	Reverse NTC (MW)
DZ00 - MA00	0.06	600	0.00	300
DZ00 - TN00	0.00	700	0.00	700
EG00 - JO00	0.29	450	0.00	450
ES00 - LY00	0.24	180	0.00	0
ES00 - MA00	4.93	900	0.00	600
LY00 - TN00	0.00	100	0.21	250
JO00 - LB00	655.20	250	0.00	0

Conclusions

We can safely conclude that during the coming winter no adequacy issues are anticipated in Algeria, Egypt, Tunisia, Jordan and Morocco, but some marginal adequacy issues might occur in Libya. On the other hand, severe adequacy issues are expected to emerge in Lebanon.

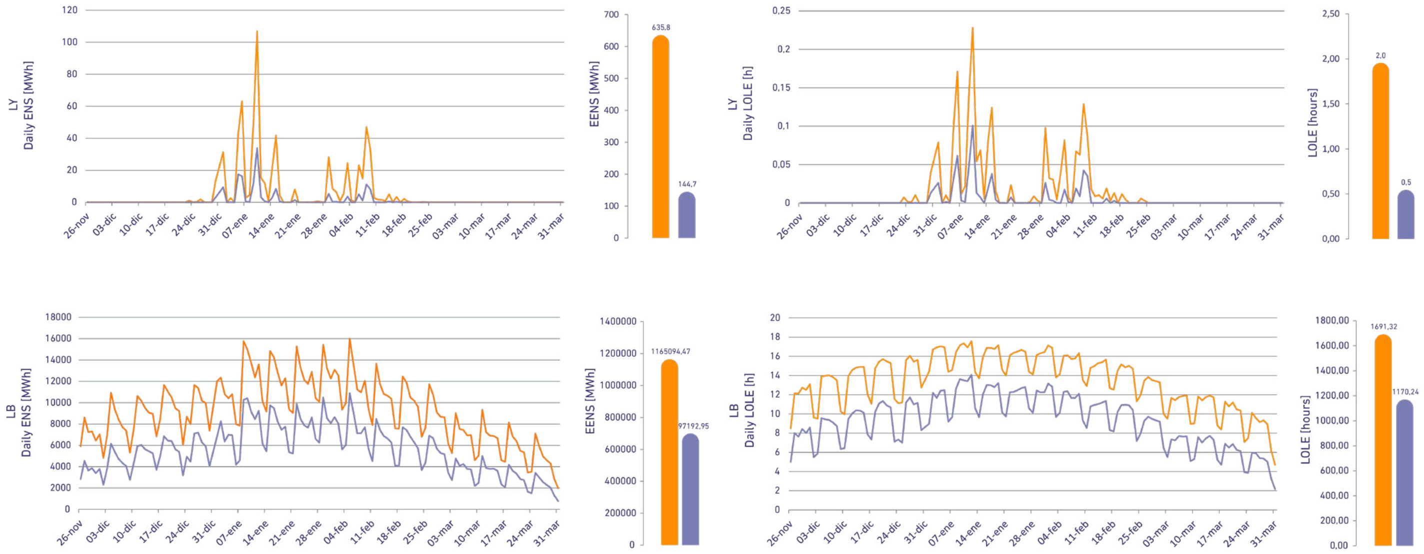

Figure 9 and 10 | Daily LOLE and EENS for the interconnected and isolated mode of operation in Libya and Lebanon

Throughout the entire winter period of 2023/2024, there is a heightened likelihood that the combined generation and imports will not be sufficient to meet Lebanon's electricity demand. The average maximum daily Loss of Load Expectation (LOLE) during the entire season could vary from 2 hours to 14 hours, with a substantial challenge of approximately 39% Loss of Load Expectation (LOLE) during the winter season alone. This situation primarily arises from the insufficiency of generation capacities within Lebanon's generation mix and limited cross-border transmission capacities.

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Med-TSO is the Association of the Mediterranean Transmission System Operators (TSOs) for electricity, operating the High Voltage Transmission Networks of 20 Mediterranean Countries. It was established on 19 April 2012 in Rome as a technical platform that, using multilateral cooperation as a strategy of regional development, could facilitate the integration of the Mediterranean Power Systems and foster Security and Socio – economic Development in the Region.

Med-TSO members share the primary objective of promoting the creation of a Mediterranean energy market, ensuring its optimal functioning through the definition of common methodologies, rules and practices for optimizing the operation of the existing infrastructures and facilitating the development of new ones.

Read more about our Adequacy Studies

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