# 2040 Mediterranean Energy Scenario Report

2025 edition

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# Abbreviations

| | |
|---|---|
| **CAGR** | Compound Annual Growth Rate |
| **$CO_2$** | Carbon dioxide |
| **EENS** | Expected Energy Not Supplied |
| **ENTSO-E** | European Network of Transmission System Operators for Electricity |
| **EV** | Electric Vehicle |
| **GDP** | Gross Domestic Product |
| **$H_2$** | Hydrogen |
| **HDEV** | Heavy Duty Electric Vehicle |
| **IN** | Inertial scenario |
| **IRENA** | International Renewable Energy Agency |
| **MA** | Mediterranean Ambition scenario |
| **Med-TSO** | Association of the Mediterranean Transmission System Operators (TSOs) |
| **MEIP** | Mediterranean Electricity Interconnection Perspectives |
| **MENAT** | Middle East, North Africa, and Türkiye |
| **NDC** | Nationally Determined Contribution |
| **NECP** | National Energy and Climate Plan |
| **OCGT** | Open-Cycle Gas Turbine |
| **P2G** | Power-to-Gas |
| **P2H2** | Power to Hydrogen |
| **PR** | Proactive scenario |
| **Prosumer** | Energy producer and consumer |
| **RES** | Renewable Energy Sources |
| **RFNBO** | Renewable liquid and gaseous transport Fuels of Non-Biological Origin |
| **TEASIMED 2** | Towards an Efficient, Adequate, Sustainable and Interconnected MEDiterranean power system |
| **ToU** | Time-of-Use tariff |
| **TSO** | Transmission System Operator |
| **TYNDP** | Ten-Year Network Development Plan |
| **EU** | European Union |

# 1

# Foreword

As part of the TEASIMED 2 project, we are pleased to publish this Scenario Report, which outlines the prospects for the evolution of electricity power systems in all Mediterranean countries by 2040.

For this new edition, following the 2022 publication[1] of the Mediterranean Master Plan, our members and experts from the Technical Committees have focused on two major challenges for the region in the coming years to 2040: the development of electric mobility and the emergence of massive hydrogen production from renewable electricity sources ('green hydrogen'), which has significant potential throughout the Middle East, North Africa, and Türkiye (MENAT).

The development of these scenarios is a prerequisite for studying and analysing new interconnection projects, which will be covered in two separate publications: the update of the Mediterranean Master Plan for 2030 and the publication of the new Mediterranean Electricity Interconnection Perspectives (MEIP) for 2040. This Scenario Report covers both timeframes and sets the framework for both publications.

1 https://masterplan.med-tso.org/

# 2

# Assumptions and modelling

## 2.1 Context and objectives of the scenario development for Med-TSO

The scenario-building process implemented by Med-TSO is conceived as the foundation for assessing future energy requirements. It is designed to provide a quantitative basis for infrastructure assessment and network planning, thereby establishing a set of plausible futures against which system performance can be evaluated. In practice, **scenarios are crafted to capture the dynamic uncertainties of the energy transition.**

The Med-TSO framework includes three scenarios: Inertial, Proactive, and Mediterranean Ambition, which reflect **potential long-term interactions among national power systems, ultimately leading to a coordinated Mediterranean Power System.** These 2040 scenarios outline pathways from the present to diverse possible future trends in energy demand, electricity generation, sector coupling, technology evolution, policies, and decarbonisation targets, providing a robust foundation for grid development studies. In the long term, the uncertainties are inherently multifaceted. For example, structural issues raised by the 2022-2023 energy crisis illustrate the complex relationship between relative energy prices and the extent of electrification in industry, heating, and transportation. There is also **uncertainty regarding the pace of development for technologies that could be crucial in the energy transition**, such as green hydrogen, but which are not yet mature.

In contrast, the level of uncertainty for the 2030 horizon (less than five years from now) remains relatively limited, leading Med-TSO to develop a **single, consolidated projection for the medium-term evolution of Mediterranean electrical systems**. This projection aligns with the NT+2030 scenario of the TYNDP2024 for European countries.

## 2.2 Integrated energy system modelling – green hydrogen

Some MENAT countries possess significant renewable resources, both in terms of performance (in certain regions of southern Morocco, Tunisia, or Egypt, the wind capacity factor can exceed 50%, or even 60%), and potentially mobilisable capacity, to play a **significant role in the low-carbon hydrogen market** (so-called renewable hydrogen, or green hydrogen) and its derivatives.

According to their distance from electrical grid infrastructures and the destination of the produced hydrogen, areas suitable for renewable hydrogen development can be connected to the electrical grid (on-grid configuration), operate in an isolated configuration (off-grid), or in a hybrid configuration.

In an export perspective mainly oriented towards Europe, the assumptions and modelling of renewable hydrogen production and its derivatives in MENAT countries have been constructed in alignment with the **EU Delegated Act 1087 of February 10, 2023**, which establishes a methodology setting out detailed rules for the certification of renewable liquid and gaseous transport fuels of non-biological origin (RFNBO). The Act outlines the **requirements for the production of renewable hydrogen that apply to both domestic producers and producers from third countries that wish to export renewable hydrogen to the EU** for it to count towards EU renewable energy targets. Specifically, this includes the potential implementation of additionality criteria indicating that the renewable energy source plants are being built in addition to other RES plants, i.e., specifically to convert primary energy into RFNBO.

It is also essential to consider the entire industrial dimension of P2G installations, especially regarding their behaviour on the electricity market as operators seek to maximise their operational profit. Notably, the Delegated Act does not prohibit electrolysis installations (also called Power-to-Gas, or P2G) from participating in the Balancing Market, particularly through upward and downward offers, similar to demand-side reserve actors. Without calling into question the compliance criteria of the Delegated Act, P2G business models must fully consider the economic viability of this industry. **This includes leveraging all the opportunities that the electricity market offers for the valorisation of the flexibility that P2G installations can propose.**

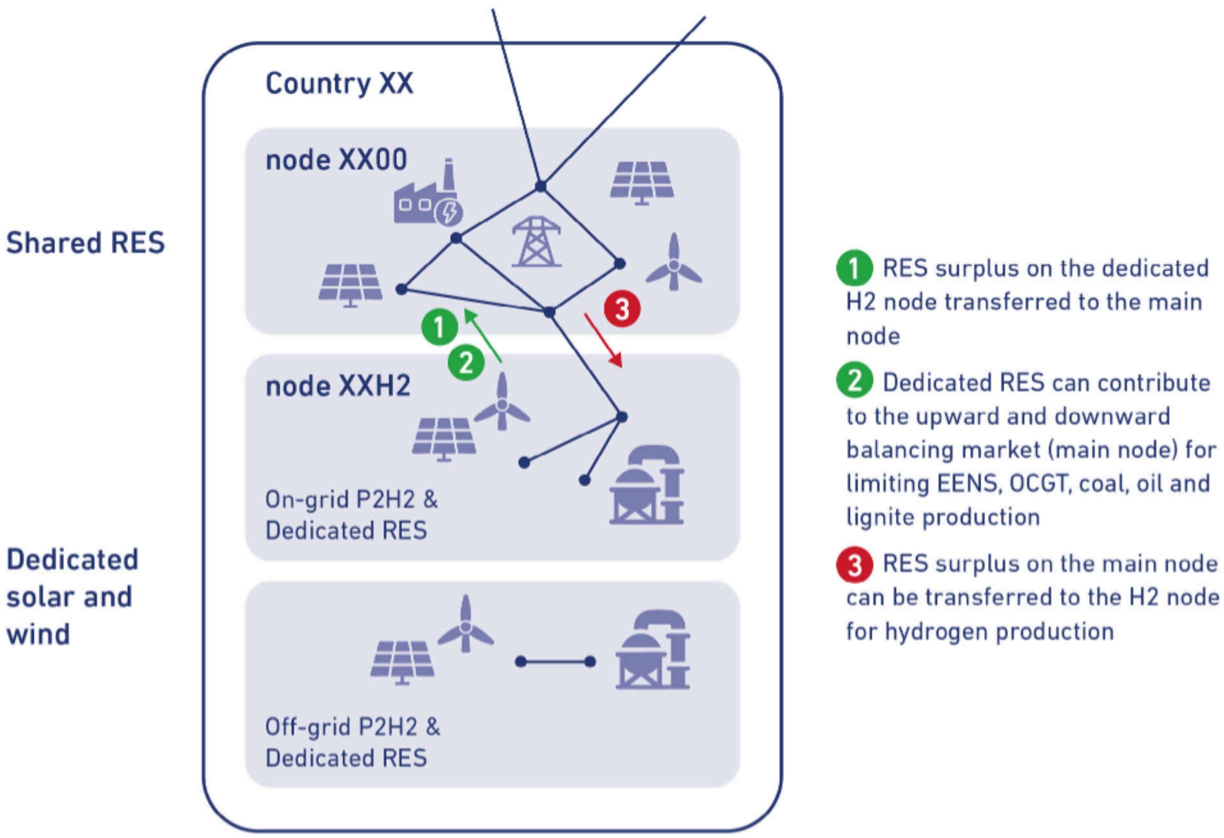
In this context, the modelling approach adopted by Med-TSO to model the behaviour of P2G operators in the power system follows the scheme presented below (Graph 1). For each country, the model structure may include three nodes:

• **A general node**, referred to here as 'node XX00', which represents the power market area and includes electrical interconnections with other countries. This node encompasses all electrical consumption and electricity production capacities not dedicated to hydrogen.

• **An on-grid green hydrogen node**, noted as 'node XXH2,' to which all or part of the renewable production dedicated to renewable hydrogen and the corresponding electrolysers (P2G units) are connected. This node is physically and functionally connected to the general node.

• **An off-grid green hydrogen node**, where renewable production and electrolysers are not connected to the general grid.

This operational scheme and its associated assumptions are built to adhere to two essential principles:




**Graph 1: Schematic description of green hydrogen modelling in MENAT countries**

• The full application of the **additionality and temporal correlation principles** to ensure **Green H2 market integrity**.

• The economic **viability of P2G business model** (including a sustainable capacity factor for electrolysers, and contribution to power system services).

In practice, this modelling results in renewable production and P2G unit behaviour that exhibit the following characteristics:

• The **dedicated wind and solar capacity is primarily used for hydrogen production**, even when fossil generation is running in the same bidding zone.

• The volume of renewable hydrogen produced **never exceeds the dedicated renewable power generation** (plus the surplus of RES generation connected on the main node), within any given time interval of the model (typically based on an hourly granularity, consistent with market mechanisms and metering devices).

• The P2G operators can **contribute to the power system balancing** market. Where physically possible, dedicated RES capacity can:

· Replace high $CO_2$-emitting generation: OCGT, coal, oil and lignite, based on price-signal.

· Inject RES surpluses into the power market.

· Contribute to preventing load shedding.

## 2.3 Electric vehicle charging modelling



The development of electric mobility is a **crucial component in the strategy of many Mediterranean countries aiming to decarbonise the transport sector.** It offers a pathway to reduce greenhouse gas emissions, improve energy efficiency, support renewable energy integration, and achieve climate goals while providing economic and public health benefits, in a context of steadily rising mobility demand in most MENAT countries.

In the absence of systemic changes in customer behaviour and charging infrastructure, **most EV charging would occur at home,** with domestic charging points typically low–power, at 3.5 kW (Level 1) to minimise the tariff and the installation cost. Considering typical users' driving behaviours, EVs would be commonly plugged in during evening hours. This may significantly contribute to increasing the evening peak demand, generating a fast ramp-up of EV electricity demand, which comes on top of the already existing critical evening ramp of the residual load. Unmanaged charging may exacerbate peak demand, requiring costly peak generation to intervene, trigger extra grid reinforcements, and exacerbate potential adequacy issues.

In response to these identified risks, **several smart charging strategies are being employed** to shift the charging profile for off-peak times to take on more of the load:

• Offering managed charging to shift home-charging times to non-peak hours, in particular through the implementation of **Time-of-Use (ToU) tariff** (based on residual load profile, ToU can be especially useful in Mediterranean countries with a high share of PV generation). This charging strategy may be combined with PV self-consumption: **charging makes the best use of electricity generated locally by PV panels.**

• **Balanced charging strategy**: The charging power is minimised according to the energy needs and the expected parking time at a certain location. This local optimisation only requires information from the EV and does not consider the state of the grid.

• **Promotion of workplace charging** to encourage more "middle-of-the-day" charging.

Some charging strategies are dedicated to heavy-duty EV, lorries, buses, vans and minibuses.

• Depot overnight charging is expected to cover about **80% of the total energy demand for HDEV.**

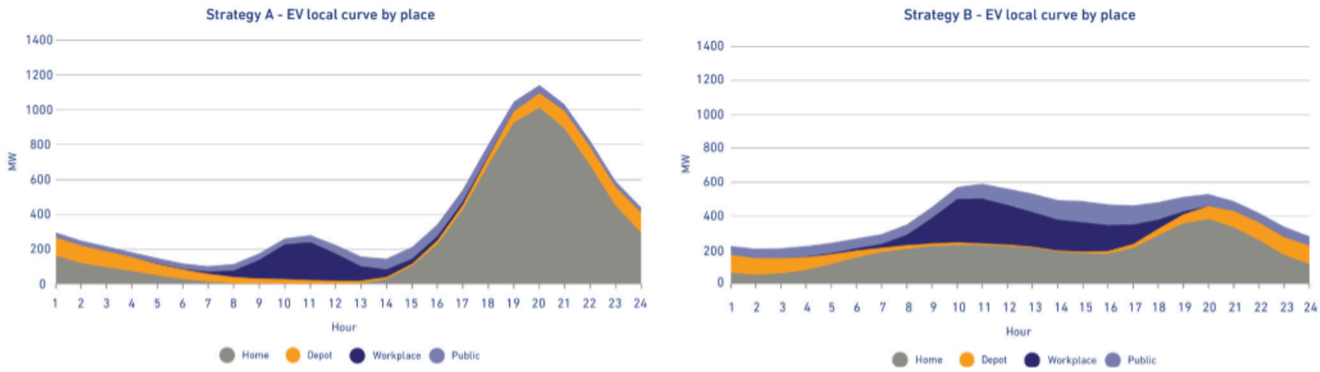
• **En-route charging along motorways** will be necessary for concluding routes in long-haul applications.

• Converting public transportation fleets to EVs should be relatively easy, **requiring high-power chargers in garages and depots** where buses are parked overnight.

In terms of modelling, two main parameters are associated with the various strategies outlined above to determine the load profiles: the **share of charging away from home, and extent of Time-of-Use tariff for EV adoption for charging.** Graph 2 illustrates (with realistic but purely illustrative numbers), the impact of these parameters for an electric vehicle fleet consisting of one million cars and 20,000 small trucks and minibuses, based on the two most contrasting strategies:

**Strategy A**
Limited use (20%) of charging away from home - large majority (80%) of unmanaged charging strategy.

**Strategy B**
Significant use (40%) of charging away from home - high-level application (50%) of Time-of-Use tariff for EV charging.




**Graph 2: Illustration of daily EV charging profile in MENAT countries**

The implementation of **highly proactive measures to control EV charging profiles can have a significant impact.** Strategy B, which combines actions promoting away-from-home charging and Time-of-Use (ToU) pricing with tariff incentives to consume during periods of lowest residual consumption (typically midday to align with peak solar production), can **reduce evening peak load demand by half compared to an unmanaged scenario.** The coordinated implementation of such measures appears to be an appropriate response to the mass development of electric mobility in Mediterranean countries, **preventing uncontrolled growth in evening peak demand in a context where solar will play a significant role** in electricity production. **Without such strategies, it would be necessary to resort to more costly solutions** (batteries, gas turbines, additional network reinforcements).

## 2.4 Scenario storylines

These Med-TSO scenarios for 2040 explore possible trajectories for future load and generation, interacting with the Euro-Mediterranean power system. The scenarios aim to build the path from the present to several possible future trends in load and generation to offer a robust framework for grid development studies

### INERTIAL SCENARIO

**No breakthrough in the midterm**

Under a scenario of moderate GDP and electricity consumption growth - factors that influence electricity demand more significantly in MENAT countries than in European countries - the Inertial scenario implies the achievement of mid-term energy targets aligned with RePowerEU and Fit-for-55 objectives for Europe. However, international cooperation remains limited beyond the European context.

In the Inertial scenario (IN), energy policies primarily prioritise local and national implementation, largely due to persistent disparities in power sector regulations among Mediterranean regions and countries. **The advancement of renewable energy sources is steadily but moderately progressing, aligning with national energy policies.** Within this context, the development of green hydrogen exhibits only marginal progress, primarily due to the absence of robust regionally coordinated policies and integration. **There is no distinct preference either towards small-scale, decentralised plants or large, centralised ones.** Overall, progress in the adoption of electric vehicles and electrification in other sectors, as well as energy efficiency measures, remains sluggish, except for a select few countries that have implemented strong incentive policies.

### PROACTIVE SCENARIO

**Bottom-up boost of distributed generation and electrical devices at the consumer level**

With a significant increase in GDP and electricity consumption, there is a stronger commitment to achieving a more sustainable energy sector, leading to an **intensified development of renewable energy sources in support of EU climate neutrality by 2050.** However, international cooperation among MENAT countries remains limited and robust energy policy integration is still lacking.

In the Proactive scenario (PR), the development of RES is primarily driven by local solutions and tailored regulations or incentives that encourage widespread investments at the consumer and prosumer level. This approach is integrated with smart energy management systems in homes and buildings.

Certain countries are **accelerating the integration of green hydrogen strategies, the adoption of electric vehicles, and promoting electrification in other end-use sectors** alongside implementing energy efficiency measures. However, significant disparities persist among countries. The implementation of distributed generation reduces reliance on grids and minimises energy losses, although interconnections remain crucial due to the higher penetration of RES.

## MEDITERRANEAN AMBITION SCENARIO

### Top-down boost for supra-national cooperation and utility-scale developments

With a notable increase in GDP and electricity consumption, there is a heightened aspiration for a more sustainable energy sector, resulting in an intensified development of renewable energy sources (and a stronger commitment to achieving climate neutrality by 2050. Moreover, there is an improved level of cooperation in the Green Transition, encompassing policy integration, financing, industry collaboration, and technology transfer.

This collaborative effort extends across the Mediterranean region, with a **multilateral and regional approach that emphasises significant advancements in energy policy integration, regulatory harmonisation, and technical cooperation** among grid operators.

In the Mediterranean Ambition scenario (MA), the significant growth of renewable energy sources is facilitated mainly through **utility-scale projects, supported by institutional agreements and international cooperation, including offtake agreements.** The abundance of carbon-free energy sources also fosters the **exploration of new applications for electricity,** such as green hydrogen, as well as deep electrification of buildings and industrial processes, which are increasingly **embraced in national and regional strategies.** Additionally, there is a **stronger impetus towards energy efficiency.** This scenario underscores the complementary nature of diverse countries' approaches in implementing large-scale projects.

Regarding EU-27 countries, both the Proactive and Mediterranean Ambition scenarios aim to reach full decarbonisation in 2050, with two contrasting pathways proposed in the TYNDP2024 approach: Proactive focuses more on renewable development and decentralised options, while Mediterranean Ambition favours a centralised low-carbon option and more electricity interconnections.

The Mediterranean Ambition scenario stands out from the other two due to one particular driver: **enhanced regional cooperation between Mediterranean countries.** This MA scenario considers major changes in energy policy integration, regulatory coordination, and technical and financial cooperation.

Among the most essential aspects that this cooperation should encompass, the industrial dimension, for example, could maximise the share of local manufacturing of energy equipment (and thereby boosting employment) in the countries concerned. **Access to the most favourable credit conditions is also crucial for supporting investments** in renewable energy and related technologies.

Most MENAT countries currently perceive the lack of tangible progress in international cooperation as an obstacle to the full implementation of the policies and investments identified to successfully achieve the energy transition.

Overcoming this obstacle will be crucial to unlocking the full potential of the region's energy resources and fostering sustainable development. **Enhanced collaboration among Mediterranean nations can pave the way for a more integrated energy market, ultimately benefiting all participating countries.**

<table>
<thead>
<tr><th>Drivers</th><th>Metrics</th><th>Inertial scenario</th><th>Proactive scenario</th><th>Mediterranean Ambition scenario</th></tr>
</thead>
<tbody>
<tr><td>Macro-economic trends</td><td>GDP/Population growth.</td><td>Small growth rate of GDP, continuous but moderate evolution of the economy, resulting in a modest ongoing growth in electricity consumption.</td><td colspan="2">Increase in the GDP growth rate compared to present trends, leading to a higher growth rate of electricity consumption.</td></tr>
<tr><td rowspan="2">Integration of energy policies</td><td rowspan="2">Green transition and Paris Agreement, decarbonisation targets achievement.</td><td>Green transition deemed to comply with current national objectives (NECP, NDP). Few international cooperations outside Europe.</td><td>For MENAT countries, there is still little international cooperation, but increased ambitions in terms of RES development. Evolution to a more sustainable energy sector intensified, despite remaining limitations induced by the weak integration of energy policies and little international cooperation.</td><td>For MENAT countries, improved cooperation in the green transition (policy integration, financing, industrial cooperation, technology transfer). MENAT countries committed with the EU in overall energy policies aimed at carbon neutrality by the middle of the century.</td></tr>
<tr><td colspan="3">For EU-27 countries, RePowerEU and/or Fit-for-55 ambition (at least -55% $CO_2$ emissions reduction in 2030 wrt 1990, 9% reduction final energy demand wrt 2020 Reference scenario, 40% RES share in the overall energy mix), and climate neutrality in 2050.</td></tr>
</tbody>
</table>

<table>
<tr><th>Drivers</th><th>Metrics</th><th>Inertial scenario</th><th>Proactive scenario</th><th>Mediterranean Ambition scenario</th></tr>
<tr><td>Integration of energy policies</td><td>Regional regulation and/or Mediterranean integration; energy independence.</td><td colspan="2">Energy policies are essentially initiated at a local and national level. Despite political ambitions in EU countries (e.g., RePowerEU plan), Euro-Mediterranean cooperation is struggling to materialise, which negatively affects massive funding needs. Significant persisting contrasts among countries in the power sector regulation.</td><td>Enhanced cooperation between the Mediterranean countries at the regional level. Major change in energy policy integration, regulation, coordination, technical and financial cooperation.</td></tr>
<tr><td rowspan="2">Power supply, RES development</td><td>RES development rate.</td><td>RES development is moderately strong, corresponding to commitments already made and national energy policies.</td><td>RES development benefits from a decentralised approach bringing local solutions that are favourable to investment and integration.</td><td>Strong RES development benefiting from international cooperation on large projects backed by institutional agreements.</td></tr>
<tr><td>Distributed [vs centralised] technologies.</td><td>No strong choice between small distributed and large centralised options.</td><td>Focus on distributed energy, initiatives at consumer level and on adapted regulation/incentives.</td><td>Focus on large-scale renewable and storage projects and related financing/business models. Opportunities depend on domestic context for distributed solution and the emerging role of prosumers.</td></tr>
</table>

| Drivers | Metrics | Inertial scenario | Proactive scenario | Mediterranean Ambition scenario |
|---|---|---|---|---|
| **New demand, electrification, and energy efficiency** | Renewable hydrogen and derivatives. | The development of hydrogen production from renewable sources in the MENAT countries is slow and mostly limited to the domestic market, while the development of hydrogen transport infrastructures in the Mediterranean is hampered by the difficulties in setting up Euro-Mediterranean cooperation. | With abundant renewable resources, several MENAT countries are proactively engaging in the renewable hydrogen industry. However, the pace of development is hampered by the difficulty to mobilise the huge financing needs and to secure long-term contracts with off-takers at the international level. | Enhanced cooperation between the Mediterranean countries at the regional level provides an appropriate response to the challenge of massive investment, regulation, and coordinated development of transport infrastructure for hydrogen and its derivatives from MENAT countries to the European market. |
| | Electrical mobility. | Modest adoption of EVs with no significant impact on demand. Some exceptions are observed in countries with stronger incentive policies. | In MENAT countries, moderately strong adoption of electric vehicles, whose development remains constrained by vehicle affordability, but also due to reasons of market accessibility and limited local industrial development. Asymmetries are observed between countries, some of which point to a strong adoption rate, leading to a relevant impact on demand. | |
| | Other electrification (heating and cooling inverter and heat-pumps, industrial heating and process electrification). | Modest electrification trend. Exceptions include climatisation technologies in some countries and rare cases of industrial new uses of electricity. | Moderately strong electrification trend. Exceptions include heating and cooling technologies in some countries, and cases of industrial new uses of electricity. | |
| | Electrical efficiency. | Modest adoption of energy efficiency measures, due to the associated investment costs. There are asymmetries across the Mediterranean region. | Moderately strong push towards energy efficiency through technological progress (availability of performing equipment and appliances), and implementation of national policies for energy-efficient behaviour and investment supporting schemes. Asymmetries between countries are relevant, with some showing a greater commitment towards energy efficiency measures. | |

**Table 1: Summary of storylines**

## 2.5. Other assumptions

The scenario-building process also includes the determination of common technical parameters.

• The principle of an **efficient day-ahead market** (or equivalent mechanisms abiding by the same core economic concepts), i.e., where electricity flows from a lower price zone to a higher price zone, independently for each hour of the day.

• The principle of **uniform wholesale fossil fuel prices** across all Euro-Mediterranean countries. While **several countries in the region are, or plan to become, producers and exporters of natural gas,** regulated pricing mechanisms may exist for domestic consumption within such countries (generally a low price that benefits the residential consumers or some export-oriented industries). These could be qualified as subsidies; if such subsidised prices were used for economic assessments, it would introduce distortions compared to optimal market-based solutions. However, the adopted principle of uniform fuel prices ensures **fair competition between thermal power plants, and enables the international electricity exchanges, which result from it, to be driven solely by fuel type and plant efficiency.** Accurate economic assessment must reflect the opportunity cost of the fuels, which correspond to international market prices where they exist, as is the case for oil and gas products.

• The principle of assigning an **economic value to $CO_2$ emissions** resulting from electricity generation, common to all Mediterranean countries. This ensures the integrity of regional mechanisms for controlling greenhouse gas emissions, even in the absence of shared

| Commodity | Fuel | 2030 | 2040 |
|---|---|---|---|
| Fuel prices €/net GJ | Nuclear | 1.68 | |
| | Lignite | 3.1 | |
| | Hard coal | 1.78 | 1.65 |
| | Gas | 6.29 | 5.65 |
| | Light oil | 11.74 | 11.38 |
| | Heavy oil | 9.63 | 9.33 |
| | Oil shale | 1.86 | 2.71 |
| Biofuels | Biomethane | 18.8 | 18.04 |
| | Synthetic methane | 27.55 | 24.99 |
| | Share in MENAT countries | 0% | |
| Hydrogen | €/Kg in MENAT countires | 1.88 | 2.05 |
| $CO_2$ | € per ton $CO_2$ | 113.4 | 147 |

**Table 2: Commodity prices**

regulatory frameworks.

## Commodity prices

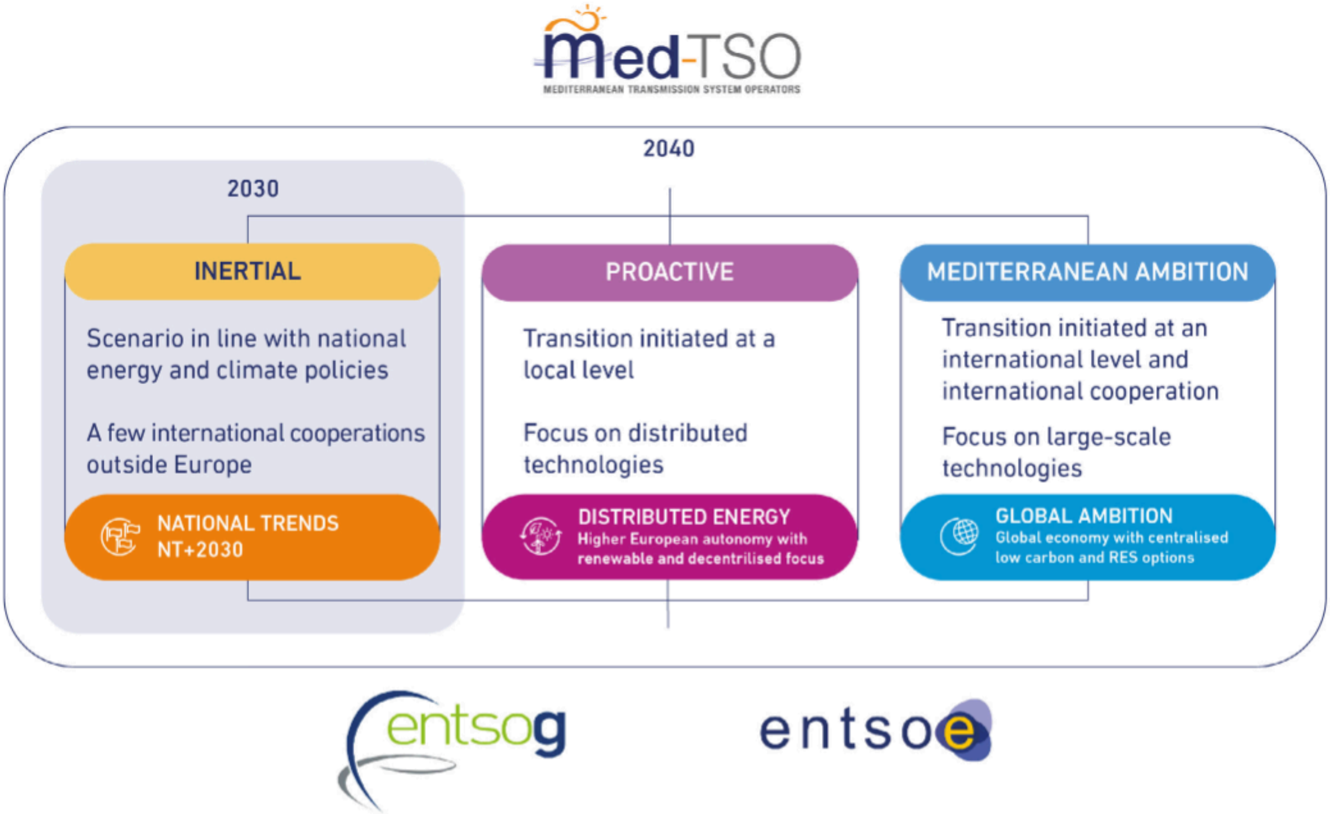
Table 2 presents the fuel and commodity prices adopted by Med-TSO for calculating the variable generation costs to be used for modelling the Euro-Mediterranean power system.

## How Med-TSO scenarios are linked to other available scenarios

The scope of power system modelling includes the whole interconnected power system, which encompasses both European and Mediterranean (extra-EU) countries. For the resulting Euro-Mediterranean power system, a key issue lies in **ensuring data consistency among TSOs** that are members of ENTSO-E, the association of European TSOs, and Med-TSO.

To facilitate such consistency, the two associations have signed a dedicated cooperation agreement and have established **a fruitful exchange of methodologies, models, and data.**

Globally, the scenario-building methodology used by Med-TSO is broadly aligned with that of




**Graph 3: Correspondence between TEASIMED 2 and TYNDP2024 scenarios**

ENTSO-E, particularly for the scenarios proposed for the **Ten-Year Network Development Plan (TYNDP) 2024**. The principle is to **examine the extent to which these drivers coincide,** and to proceed with scenario coupling by **favouring maximum coherence in the underlying drivers.**

Following a driver-based approach, Med-TSO scenarios are matched with the most similar ENTSO-E scenarios for European countries, as shown below.

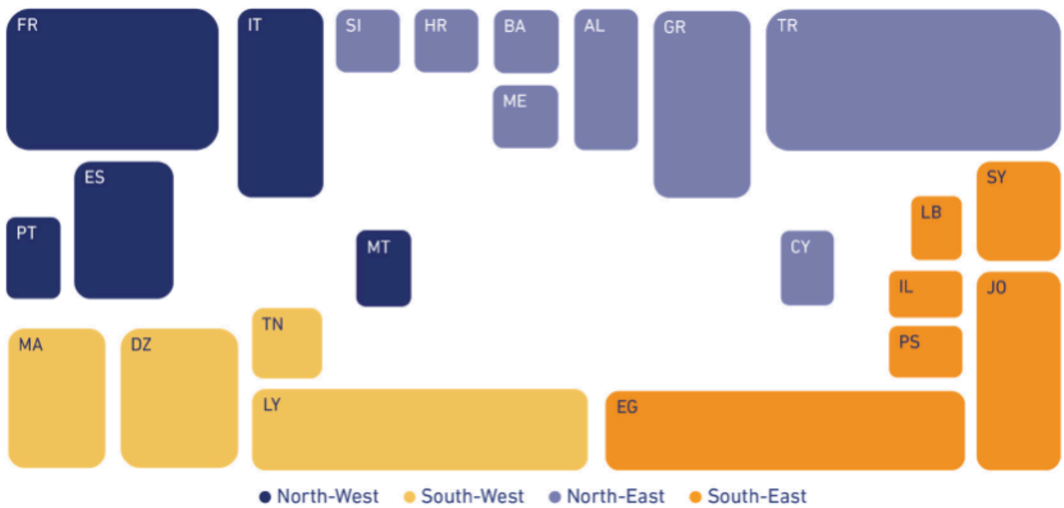
Both Med-TSO Inertial and TYNDP2024 National trend (NT+) scenarios share a focus on the achievement of **already decided actions and decisions related to energy and environmental policies** (Fit-for-55 and RePowerEU for EU-27 members, and pre-approved energy policies and action plans for other countries).

Although Med-TSO and ENTSO-E scenarios are conceptually aligned as summarised above, some discrepancies may arise due to contrasting regulation frameworks. Similar inconsistencies might also exist between Med-TSO's scenarios and those developed by TSOs at the national level.

3

# Electricity demand and generation capacity projection

All figures presented in this report correspond to the Mediterranean countries, which include all Med-TSO members plus Bosnia Herzegovina, Malta, and Syria, as shown on the block diagram below. The Mediterranean countries are grouped into four sub-regions: North-West, North-East, South-West, and South-East, as depicted in the following colour coding.




**Graph 4: Mediterranean countries and grouping**

## 3.1 Electricity consumption perspectives

The following table shows the projected annual electricity consumption for all Mediterranean countries up to 2040 under the three scenarios. The reference year is 2023. **The scope of electricity consumption incorporates all uses of electricity (losses included), and new uses such as electric mobility.** It also includes the share of consumption satisfied by local production (for example, self-production through rooftop solar panels in the residential sector). However, the electricity demand for electrolysis, which constitutes an energy transformation from electricity to hydrogen, is excluded from the electricity consumption scope.

| | 2023 | 2030 | 2040 | | |
|---|---|---|---|---|---|
| | Mediterranean countries | Mediterranean countries | Inertial | Proactive | Mediterranean Ambition |
| **Electricity consumption (TWh)** | **2052** | **2473** | **2897** | **3006** | **3057** |
| **Consumption increase** | - | +20% | +41% | +46% | +49% |
| **Compound annual growth rate (CAGR)** | - | +2.7% | +1.6% | +2.0% | +2.1% |

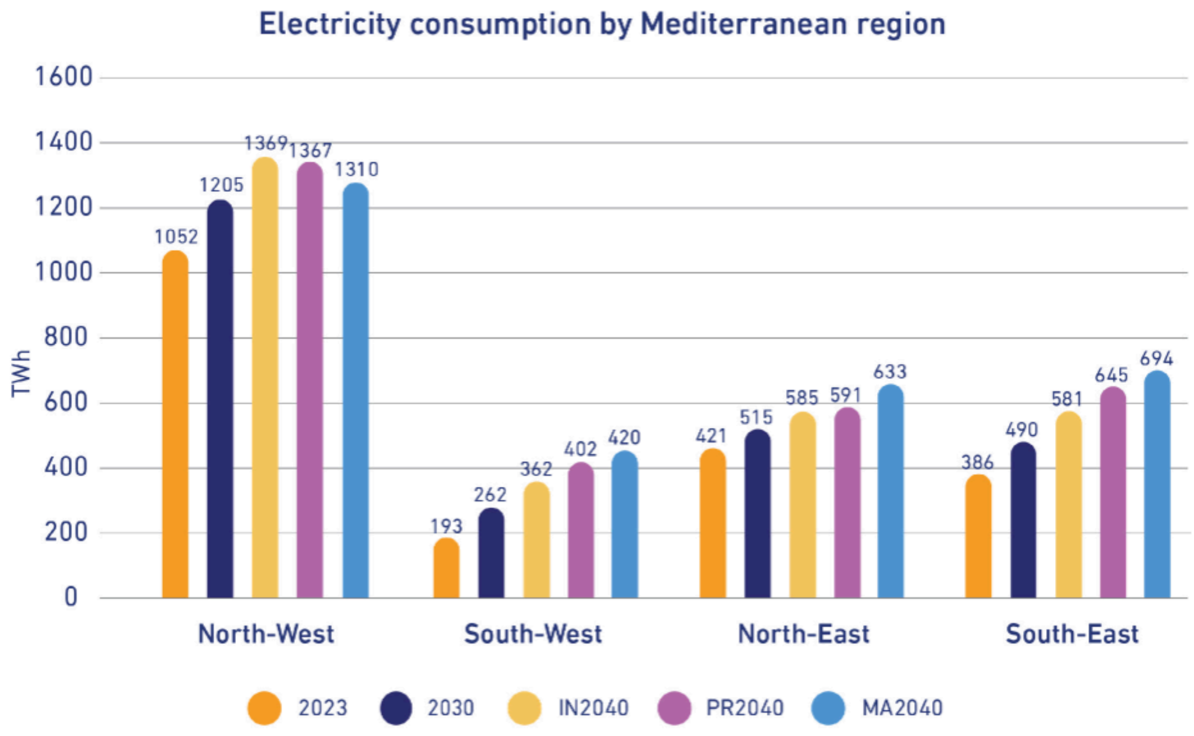
**Table 3: Electricity consumption projections by 2040**

The 2030 projection forecasts **an acceleration of the historical growing trend over the current decade, with consumption by 2030** reaching around 2470 TWh, representing an increase of 20% compared to 2023. This corresponds to an average annual growth rate of +2.7%.

By 2040, the electricity demand is estimated to be between 2,900 and 3,060 TWh, depending on the scenario, representing an increase of approximately 40% to 50% compared to the reference year 2023. Over the decade from 2030 to 2040, the average annual growth rate is expected to range from +1.6 to +2.1%. **The higher consumption levels in the Proactive and**

**Mediterranean Ambition scenarios, compared to the Inertial scenario, can be explained by a more favourable economic growth assumption** (this factor remains the most decisive factor in North Africa, Middle East countries and Türkiye), as well as **stronger electrification of the energy sector** (mobility, industry, heating processes, etc.).

This overall growth includes contrasting dynamics between Mediterranean countries. The evolution of electricity consumption varies significantly among the Mediterranean countries, looking at both the past trends and the 2030 and 2040 outlooks, as illustrated below.




**Graph 5: Electricity consumption by Mediterranean region**

In European countries, particularly the North-West group, the **notable growth in direct electrification** reflects Europe's broader strategy to phase out fossil fuels, underscoring the **region's commitment to improving energy efficiency and accelerating decarbonisation** (the transportation sector stands out as the primary driver behind the growth in electricity demand).

In MENA countries, the impact of increased electrification is more visible in the Mediterranean Ambition scenario, especially under the assumption of **implementing regional cooperation policies across the Mediterranean.** Conversely, **electricity consumption appears slightly lower** in Europe (and some MENA countries) under the Mediterranean Ambition scenario due to **increased use of hydrogen, particularly in industry and transportation.**

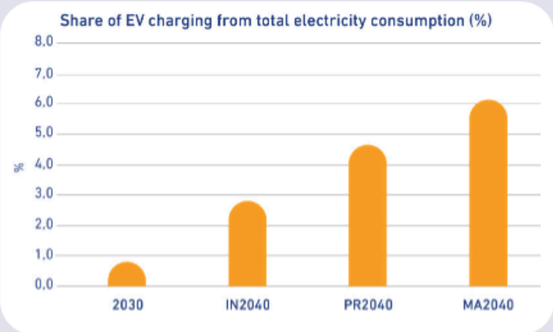
## Box 1: Electric vehicle charging demand in MENAT countries

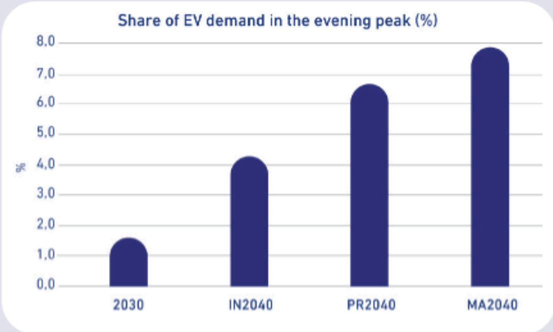
The electric vehicle (EV) fleet in the South-Eastern and South-Western Mediterranean countries **remains limited and at an early stage of development.** It is not yet considered significant compared to global standards.

However, there is growing momentum and **potential for expansion in the future as awareness grows and infrastructure improves.**

The share of EV charging from total demand is expected to nearly triple from 2030 to 2040. It will represent **a major component of evening peak demand,** increasing from approximately 1.5% in 2030 to between 4.5% and 8% by 2040. To manage this load effectively and shift EV charging peak load away from the national peak demand periods, countries will need to **raise national awareness and apply new regulations,** such as Time-of-Use tariffs.

The following two graphs show the share that electric vehicle charging could represent in 2030 and 2040 for all MENAT countries, in annual energy on the left graph, and in contribution to the evening peak consumption power on the right graph.

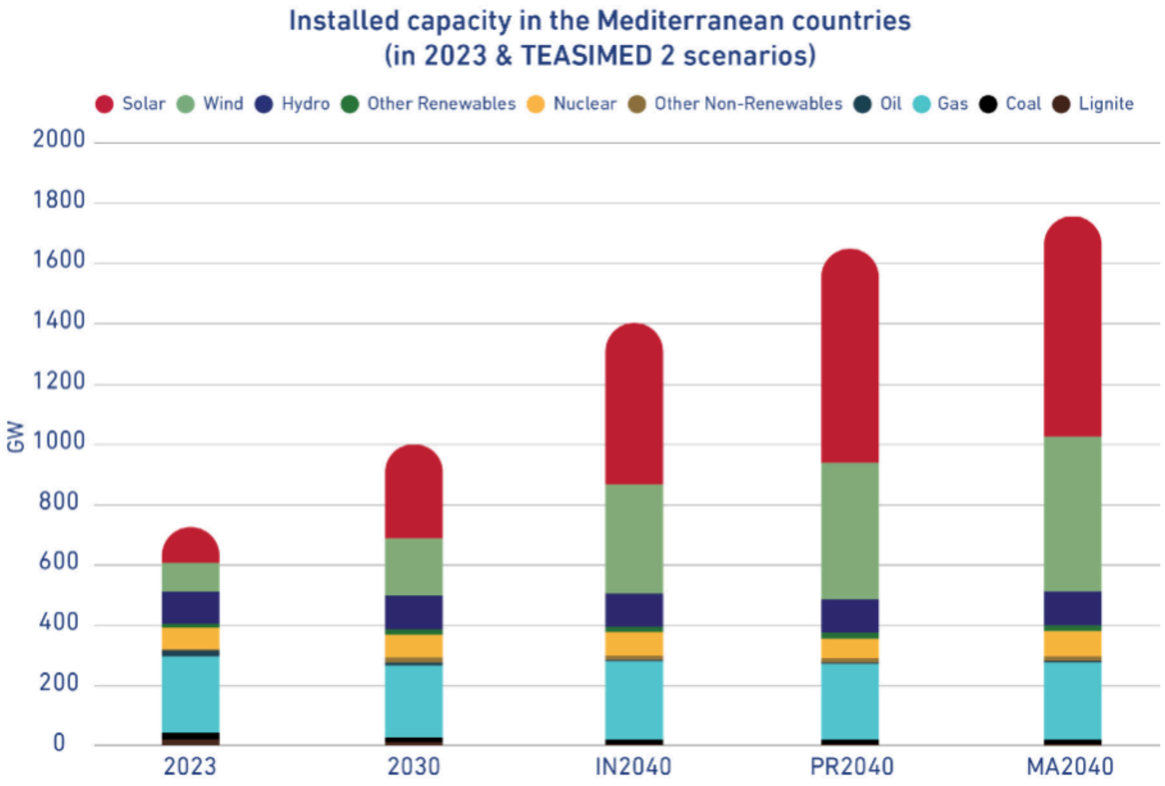



**Graph 6: Share of EV charging in MENAT countries**

## 3.2 Generation capacity

In the context of the energy transition, decarbonisation, and electrification of final consumption, **power generation facilities in the Mediterranean region will undergo significant changes.** The following figure presents the installed generation capacity in 2023, 2030, and according to the three scenarios for 2040, based on the respective primary energy source.




**Graph 7: Installed generation capacity in the Mediterranean**

This figure illustrates that compared to the reference year 2023, the **growth in electricity installed capacity is almost exclusively focused on solar and wind energy.** Overall, RES account for 46% of the total installed production capacity (excluding storage capacity) in 2023, with 63% projected in 2030, and between 73% and 79% expected in 2040.

The most significant trend regarding thermal power plants involves the **most polluting and $CO_2$-emitting plants.** The cumulative capacity of coal-fired power plants across all Mediterranean countries decreases from 23 GW in 2023 to 14 GW in 2040 (in the three scenarios, with three-quarters of this capacity installed in Türkiye in 2040). Lignite-fired power plants are only marginally present by 2040 (4 GW, solely in the North-East region, Türkiye, and certain Balkan countries).

Gas-fired power plants represent most of the thermal power fleet, and their cumulative installed capacity would remain largely stable (approximately 250 GW) by 2040 across all Mediterranean countries. Specifically, **the fleet of gas-fired power plants is significantly decreasing in the North-West region** (dropping from about 110 GW in 2023 to 80 GW in 2040), while **the rest of the Mediterranean region would see growth in this technology.**

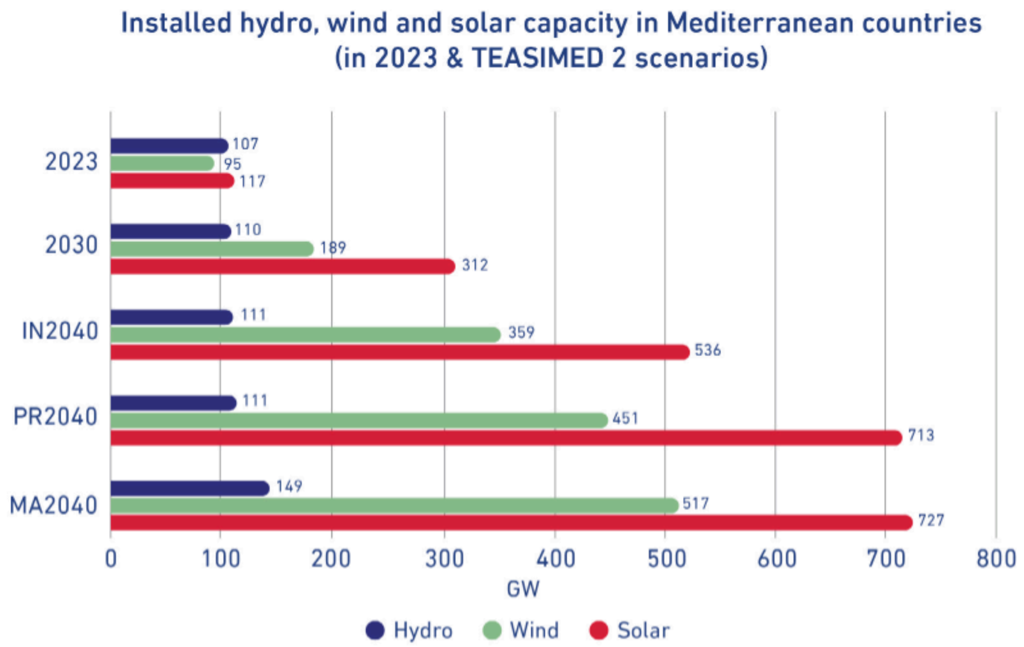
The situation regarding nuclear power plants is also varied. By 2030 and 2040, new production sites are planned in Türkiye (approximately 9 GW) and Egypt (nearly 5 GW). In Spain, however, existing plants (approximately 7 GW) are expected to be shut down by 2040 across all three scenarios. For France, the outlook for 2040 remains divergent across the three scenarios (between 50 and 66 GW).

## 3.3. Renewable generation capacity

Of all the electricity generation sectors in all scenarios, renewables account for most of the growth, with remarkable momentum. Indeed, considering all renewable technologies combined, their cumulative capacity for all Mediterranean countries is expected to increase from approximately 330 GW in 2023 to an estimated 630 GW in 2030, and then between 1,030 and 1,370 GW expected in 2040, depending on the scenarios. These figures include renewables specifically dedicated to green hydrogen production.

The figure below presents the outlook for 2040 for the three most developed renewable technologies in the Mediterranean region for electricity production: **hydropower, solar, and wind.**

With particularly abundant natural resources and already having a strong presence in the region, **solar development will continue at a rapid pace due to attractive production costs** and



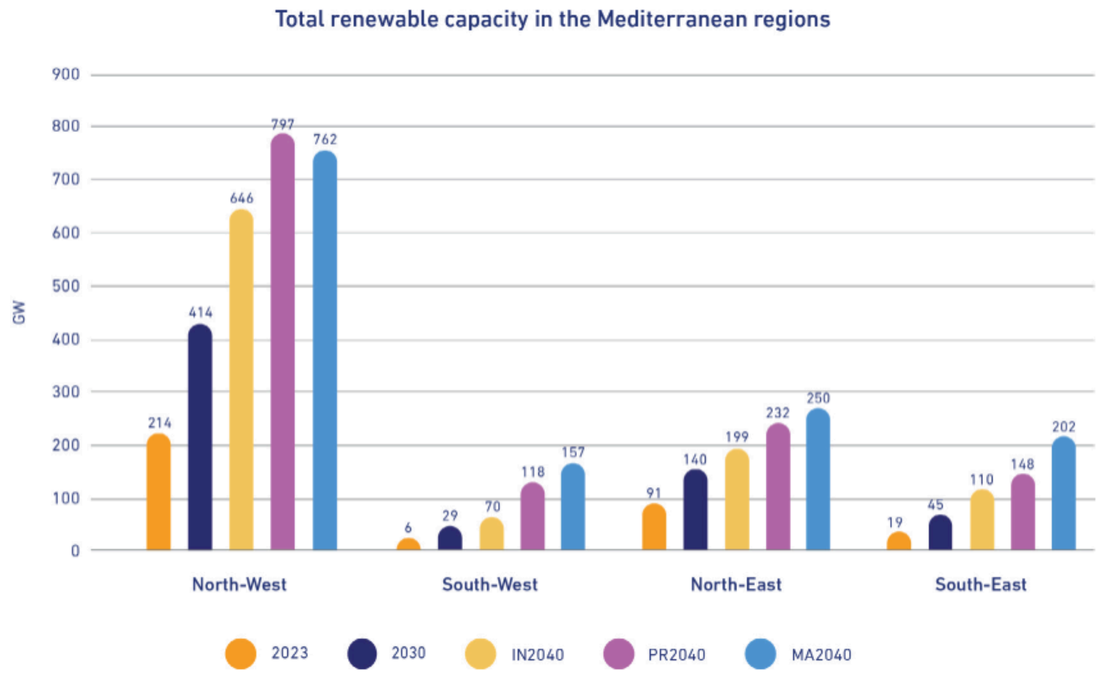

**Graph 8: Installed hydro, wind and solar capacity in the Mediterranean**

seasonality that aligns well with demand. Depending on the scenarios, **the installed capacity in 2040 could be four to six times higher than 2023.** In North Africa and the Middle East, the equivalent full-load hours for solar range from 1,800 to 2,300 hours and can reach 2,600 hours under the most favourable conditions by using one-axis tracker technology, which is now increasingly deployed in large utility-scale installations.

Although less impressive than solar, **wind development will also continue at a marked pace in the Mediterranean,** with an increase in installed capacity by a factor of 3 to 4, depending on the scenarios, by 2040 compared to 2023. **In some MENAT countries, wind conditions can be exceptionally favourable for wind development** (for example, southern Morocco, eastern Egypt, particularly near the Red Sea, southern Tunisia, etc.), with capacity factors that can reach 50%-60% in certain locations.

The figure below indicates the progression of renewable energies across Mediterranean regions.

While the Northwest region (France, Italy, Spain, and Portugal) shows the strongest current



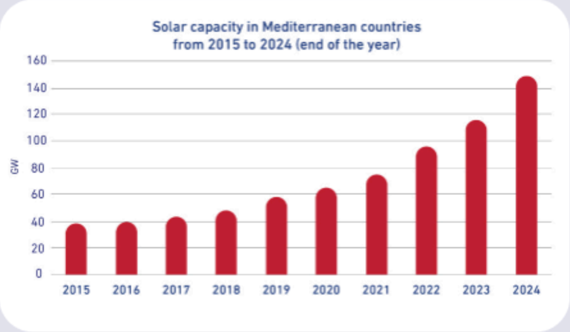

**Graph 9: Total renewable capacity in the Mediterranean regions**

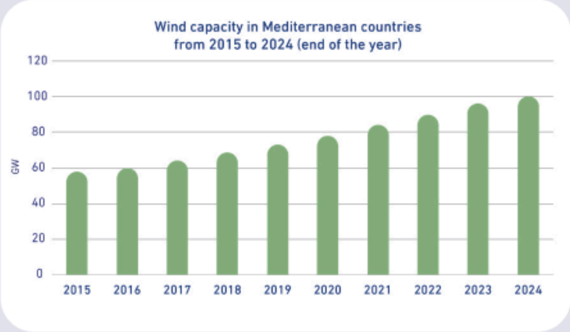
advancement and the highest prospects for renewable development, the overall trend is well distributed across the entire Mediterranean region. **Several other countries have also been engaged in massive renewable development for several years** (for example, Türkiye and Morocco), although this trend is more recent for other MENAT countries, as indicated in the following box.

**Box 2: Why RES development is anticipated to break from past trends by 2030**

The renewable energy share projected for 2030 represents a marked break from past trends, **highlighting a deliberate and strategic shift.** This transition is driven by several key factors, the foremost being policy acceleration. EU and non-EU Mediterranean countries have increasingly set clear and defined targets for decarbonisation and the transition to sustainable energy systems in their respective national strategies and according to their international commitments under the Conference of the Parties (COP). These frameworks set out **clear, defined targets for decarbonisation and the transition to sustainable energy systems.** Consequently, achieving these objectives will require a substantial acceleration in the deployment of renewable energy across the region between now and 2030.

Moreover, **the continued and notable decline in the costs of solar and wind energy, combined with the increased deployment of battery storage, is enhancing the attractiveness and the competitiveness of renewable energy sources** relative to fossil fuels. This trend is already evident in the **growing number of renewable energy projects currently in the commissioning or tendering stages,** as confirmed by feedback from Med-TSO members. Further confirmation of this trajectory can be found in the most recent statistics on renewable energy deployment in the Mediterranean, as published in early-2025 by the International Renewable Energy Agency* (IRENA).




**Graph 10: Solar and wind installed capacity in Mediterranean countries from 2015 to 2024**

Considering the most recent trends and observed progress, the 2030 **targets for installed solar energy capacity appear to be achievable at the current pace.** However, meeting the corresponding targets for wind energy deployment will require increased efforts and accelerated action in the coming few years.

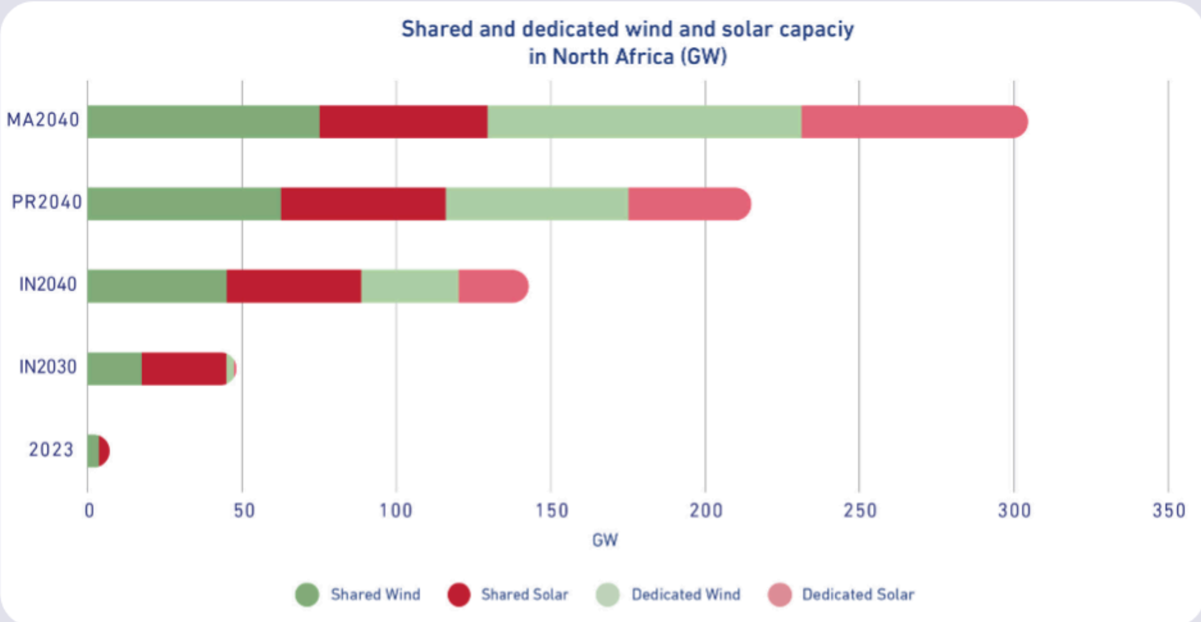
* Source: IRENA - https://www.irena.org/Publications/2025/Mar/Renewable-capacity-statistics-2025

**Box 3: Zoom in on dedicated RES for green hydrogen production in North Africa**

Most MENAT countries have published roadmaps and/or national strategy documents in recent years, focused on production of renewable hydrogen and its derivatives for domestic and global markets, leveraging their cost-effective and abundant wind and solar resources.

Thanks to the most **favourable renewable resources, as well as industrial synergies and opportunities** (particularly in the fertiliser sector), the **highest ambitions for green hydrogen production are held by Morocco, Tunisia, and Egypt.**

The graph below presents the development prospects for solar and wind capacities across North African countries. It distinguishes, on the left side of the graph in dark colours, renewables not dedicated to hydrogen (also known as shared RES), and on the right side in light colours, renewables specifically dedicated to green hydrogen production.




**Graph 11: Shared and dedicated wind and solar capacity in North Africa**

The development of the renewable capacities dedicated to renewable hydrogen production is expected to emerge mainly after 2030, primarily in the Mediterranean Ambition scenario due to **ambitious prospects for international cooperation.**

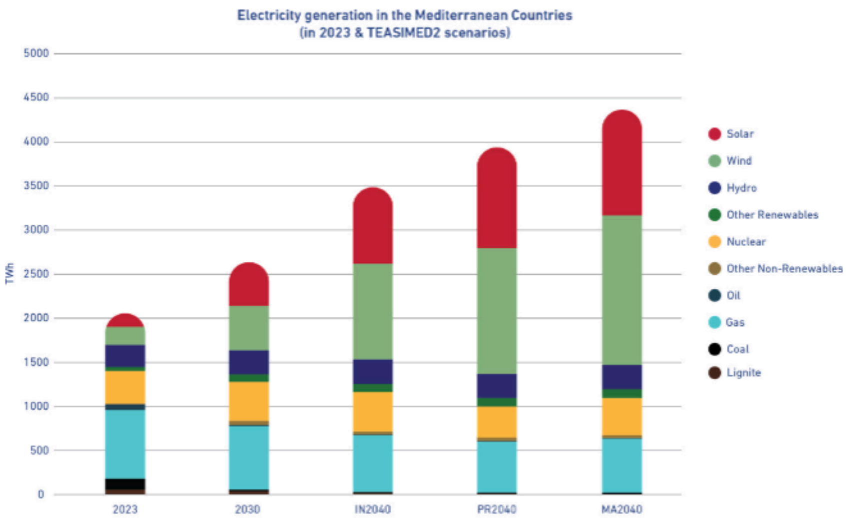
This graph clearly illustrates that the development of renewables dedicated to green hydrogen does not hinder the overall development of renewables associated with the decarbonisation of the electricity production sector, thereby aligning with the European regulation and the spirit of the additionality principle. On the contrary, **the green hydrogen sector enables a doubling, or even more, of renewable capacities in the Mediterranean Ambition scenario, potentially reaching 300 GW by 2040 in North Africa.**

# 4

# Electricity Generation and $CO_2$ emission perspectives

## 4.1 Generation and renewable share

In the context of a significant increase in the installed capacity of renewable energy, the graph below illustrates the **projected evolution of electricity production in the Mediterranean region up to 2040** under the different scenarios. This increase is driven by the need to meet both the growing electricity consumption and the specific demand for green hydrogen production.




**Graph 12: Electricity generation in the Mediterranean countries**

Overall, electricity production in the region is projected to grow by 30% in 2030 compared to the baseline year of 2023, and by 70% to 110% in 2040, depending on the scenario considered.

By 2030, and even more so by 2040, **the most polluting and $CO_2$-emitting thermal power plants (coal, lignite, and fuel oil) would occupy a minimal role in the Mediterranean electricity** mix, accounting for less than 1% in 2040 across all scenarios, compared to 11% in 2023. The production capacity of gas-fired power plants would also see a reduction, although to a much lesser extent, decreasing from approximately 780 TWh in 2023 to 600 TWh projected in 2040, despite a similar installed capacity.

Unsurprisingly, **the growth in electricity production will be entirely met by renewable energy sources for all regions combined.**

The following table illustrates the proportion of the total electricity demand in Mediterranean countries (including the electricity demand dedicated to green hydrogen production) which is met by renewable energy sources.

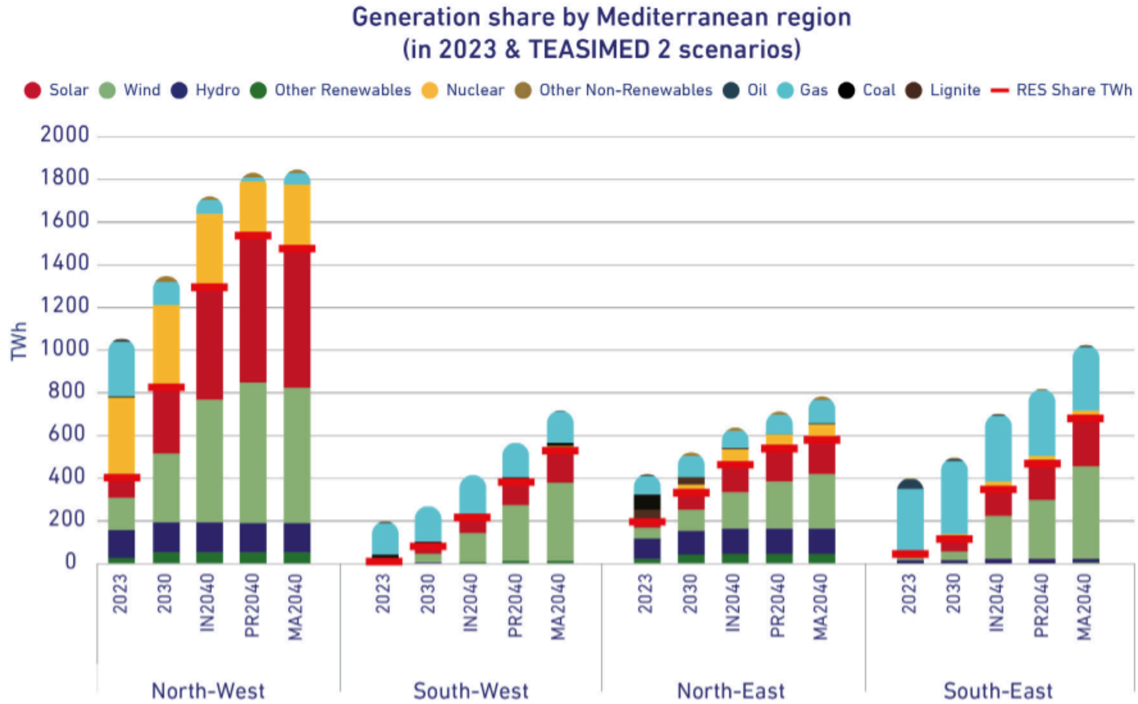
| | 2023 | 2030 | 2040 | | |
|---|---|---|---|---|---|
| | Mediterranean countries | Mediterranean countries | Inertial | Proactive | Mediterranean Ambition |
| **Share of electricity demand covered by RES** | **31.8%** | **53%** | **70%** | **78%** | **79%** |
| **Wind generation** | 10.3% | 19% | 33% | 38% | 41% |
| **Solar generation** | 7.3% | 19% | 26% | 30% | 29% |
| **Hydro generation** | 12.0% | 11% | 8% | 7% | 7% |

Table 4: Share of electricity demand covered by renewable energy

While the **share of renewable energy production is about one-third in 2023, it is expected to exceed 50% by 2030** and could account for up to 70% to 80% of the total demand by 2040, depending on the scenarios. Wind energy alone could supply up to 40% of total demand. **This represents a major shift in the nature of Mediterranean power systems, which will need to adapt to the widespread integration of these technologies.**

It is important to note that the renewable energy production that may potentially be lost due to surplus situations is not subtracted in this table (i.e., renewable production before RES curtailment). The annual energy from renewable sources that could be curtailed is estimated to reach the equivalent of 1% of the total electricity demand by 2030 and between 3% and 4% by 2040.

The figure below indicates the progression of electricity generation across Mediterranean regions.




**Graph 13: Electricity generation by Mediterranean region**

A significant portion of the increase in renewable energy production in the South-West and South-East regions is driven by green hydrogen production, particularly in the Mediterranean Ambition scenario.

## 4.2 Green hydrogen production in North Africa

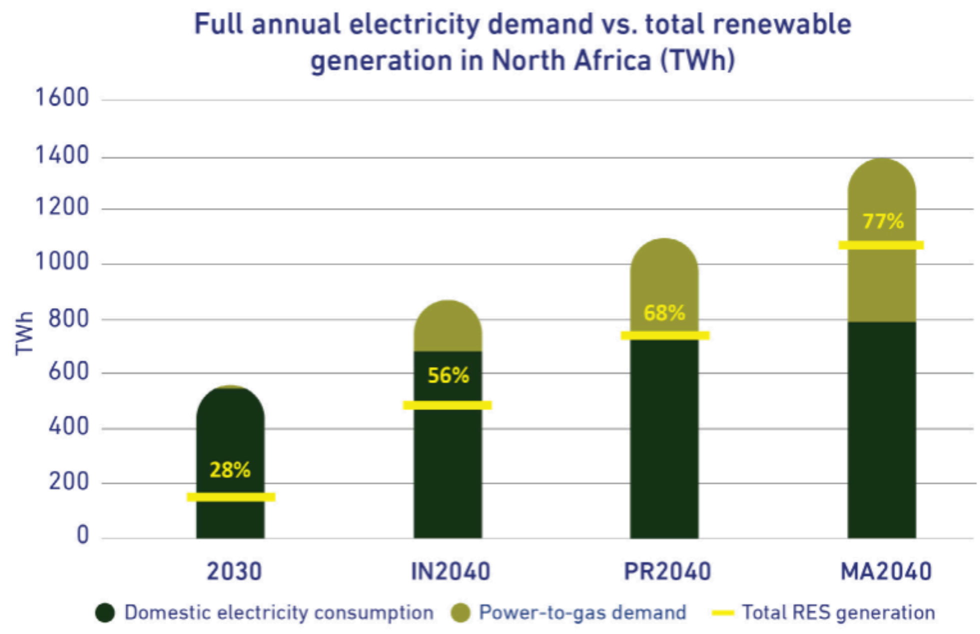
The figure below indicates the outlook for the green hydrogen production in North Africa, according to the scenario considered.

| | 2030 | 2040 | | |
|---|---|---|---|---|
| | North African countries | Inertial | Proactive | Mediterranean Ambition |
| **Green hydrogen production (million ton)** | **0.28** | **3.8** | **7.1** | **12.1** |
| **Electrolysis installed capacity (GWe)** | 2 | 28 | 52 | 90 |
| **Renewable electricity demand (TWh)** | 14 | 190 | 350 | 600 |

**Table 5: Green hydrogen production in North Africa**

Barely emerging by 2030, **green hydrogen production in North Africa could range from 4 to 12 million tonnes by 2040,** depending on the scenario considered. In the Mediterranean Ambition scenario, this production would require dedicating 600 TWh of renewable electricity to supply electrolysers.

To illustrate the extent to which the green hydrogen industry could transform the energy sector in North Africa, the following graph compares the electricity consumption for end-uses (including electric mobility) with the electricity demand specifically dedicated to power-to-gas (electrolysis) operations. The graph also indicates the share of this total demand (including electrolysis) that is met by renewable electricity.




**Graph 14: Total electricity demand vs RES generation in North Africa**

It is quite remarkable to note that renewable production could reach (Proactive scenario) and even far exceed (Mediterranean Ambition scenario) the end-uses of electricity consumption for all North African countries combined. **Green hydrogen production constitutes a powerful lever to a major new outlet for the development of renewables in this region.** By doing so, it can contribute to global decarbonisation (primarily in Europe) through the export of green hydrogen and its derivatives.

## 4.3 $CO_2$ emissions perspectives

While the significant **reduction in the use of the most polluting and $CO_2$-emitting power plants in the Mediterranean region raises hopes for a decrease in $CO_2$ emissions,** the following table provides quantified perspectives for this reduction in the electricity production sector.

| | 2023 | 2030 | 2040 | | |
|---|---|---|---|---|---|
| | Mediterranean countries | Mediterranean countries | Inertial | Proactive | Mediterranean Ambition |
| **Reduction of $CO_2$ emissions (Mt)** | **(494)** | **-36%** | **-50%** | **-55%** | **-53%** |
| **$CO_2$ content of electricity ($gCO_2$/kWh)** | 256 | 126 | 75 | 60 | 56 |

**Table 6: Reduction of CO2 emissions in the Mediterranean**

While total Mediterranean electricity demand could increase by nearly 30% by 2030 compared to the reference year 2023, $CO_2$ emissions from the sector are expected to decrease by 36%. This trend can be explained by two major factors: the **significant reduction in the use of coal and lignite power plants** (no plants equipped with carbon capture and storage are included in any Mediterranean scenario) and the **massive development of renewable energy sources. By 2040, this phenomenon is expected to amplify, with emissions projected to be halved compared to 2023.** The $CO_2$ content of electricity produced in the Mediterranean region, expressed in grams of $CO_2$ per kWh, is expected to be halved between 2023 and 2030, and halved again in the following decade.

## 4.4 Comparison with previous Med-TSO projections for 2030

This Scenario Report builds upon previous projects conducted by Med-TSO. Although TEASIMED 2 is the first study to focus on the 2040 horizon, it can be insightful to **compare the main trends for the 2030 horizon** in terms of electricity consumption and the development of renewable energies.

The following table contrasts the perspectives from two previous studies: the Mediterranean Project 2 (MP2) published in 2020, and TEASIMED 1 published in 2022.

| | 2015 | 2023 | 2030 | | |
|---|---|---|---|---|---|
| | Mediterranean countries | Mediterranean countries | MP2 | TEASIMED 1 | TEASIMED 2 |
| Electricity consumption (TWh) | ★ 1926 | ★ 2052 | 2633 – 2472 | 2693 – 2403 | ★ 2473 |
| Share of electricity demand covered by RES | ★ 23.0% | ★ 31.8% | 46% – 44% | 55% – 46% | ★ 53% |

Table 7: Benchmark with the previous Med-TSO studies

As previously anticipated, the **new projection for electricity consumption in 2030 confirms a clear increase compared to 2015-2023.** However, it stands at the base of the previous uncertainty margins, reflecting updated socio-economic perspectives. It seems prudent, however, to assume that **new updates will adjust these projections to fully integrate the consequences of the most recent crises** (e.g., the Russian gas crisis in Europe, the evolving global competition in the industrial sector) and the increasing difficulties toward a wider electrification of the energy sector. **The acceleration of RES penetration is confirmed** with the new projections for 2030, which stand at the top of the previous uncertainty margins. This reflects **both the latest observed trends and the ambitious targets announced by national power systems.**

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