EXECUTIVE SUMMARY

MED & Italian Energy Report 2025

Energy security in the Mediterranean transition: electrification, critical raw materials and technologies

7th Annual Report

The energy transition towards decarbonization requires balancing energy security, environmental sustainability and affordability.

- The energy transition towards decarbonization requires to adequately balance energy security, environmental sustainability, and economic affordability — the three attributes of the so-called Energy Trilemma. Security will become increasingly relevant due to the strategic dependency of Mediterranean countries on major suppliers of fossil fuels and Critical Raw Materials (CRMs) used to manufacture most of the technologies employed for the transition itself.
- Three frontiers of energy security can be identified: the dependency on energy resources (fossil fuels, electricity and nuclear fuel); the technological dependency on the major suppliers of CRMs, semi-finished products and finished products; and the reliability and flexibility of domestic energy infrastructures.
- **In the EU27, the quasi-total absence of domestic resources has historically made Member States dependent on their major producers. In 2023, Norway, the USA and Algeria alone accounted for 50% of the EU's natural gas imports, with the former two also being the second and first suppliers of crude oil respectively, accounting for 28% of total imports.** Among the countries of the Mediterranean Basin, Libya contributed for 7% of the EU's crude oil imports. The concentration of resources, and the consequent limited diversification of the supply mix, make supply chains particularly vulnerable and expose supplies themselves to dangerous price volatility dynamics.
- The transition towards decarbonisation requires an increased capacity of energy technologies based on the exploitation of Renewable Energy Sources (RES), manily solar photovoltaic (PV) and wind. However, **the expected growth will inevitably entail a simultaneous global increase in the demand for the CRMs needed for their construction, estimated to be six times larger than 2022. The almost total absence of Mediterranean domestic reserves and production/refining capacity for these materials risks creating new constraints of technological dependency on the respective main suppliers.**
- **At the EU level, the *Critical Raw Materials Act* in 2024** set out guidelines to mitigate the effects of Member States' dependence on imports of critical raw materials. The document **set** (non-binding) **targets encouraging them to contribute for at least 10%, 40% and 25% of the EU's demand for critical materials through domestic extraction, processing and recycling, respectively.** In addition, imports of a specific material from a single supplier must not exceed 65% of its total imports.

The plans for developing the transition in the Southern Mediterranean countries set extremely ambitious targets for installed capacity and investment. Starting from the late 1990s, initiatives for cooperation and energy development in the Mediterranean have been launched, but their effectiveness has historically been limited by the absence of a common approach and a long-term strategic vision.

- The report provides the demand for energy and non-energy resources in the Mediterranean Basin in 2030 and 2040, based on projections carried out by Med-TSO, ENTSO-E and ENTSOG in their respective energy scenarios. The original numerical figures are drawn from the *Mediterranean Masterplan of Interconnections* (2022) of the first and the *Ten Year Network Development Plan* (TYNDP, 2024) of the other two.
- Both sources propose scenarios for the evolution of the Mediterranean energy system with different levels of effort and ambition: **according to projections, the total installed electricity capacity in the Mediterranean Basin could grow from 896 GW to 1,137 GW in 2030, starting from a value of 781 GW in 2024. Similarly, the total Mediterranean electricity demand, which stood at 2,106 TWh in 2023, could increase from 2,387 TWh to 2,887 TWh in 2030**.
- **Starting from the late 1990s, initiatives to foster the cooperation and energy development in the Mediterranean Basin have been brought forward, the first of which having been the *Mediterranean Organisation for Energy and Climate* (OMEC, 1988) and the *Barcelona Declaration* (1995).** However, despite the numerous attempts to promote regional integration, their effectiveness has historically been limited by the absence of a common approach across the three Mediterranean shores, as well as by the lack of a long-term strategic vision, especially in the countries of the Eastern and Southern shores of the Basin, where frequent geopolitical instabilities cripple the effectiveness of the efforts directed towards sustainable development.
- **In October 2025, the European Commission published the *New Pact for the Mediterranean* with the aim of encouraging and promoting cooperation among the countries of the Basin.** The Pact, which will precede the release of an Action Plan in the first quarter of 2026, is part of the broader framework of *Projects of Common Interest* (PCIs) of the Commission, which include several **new strategic interconnections such as the power lines ELMED between Italy and Tunisia (600 MW, 850 M€), GREGY between Egypt and Greece (3,000 MW, 3.6 G€), and the**

Great Sea Interconnector between Greece, Cyprus and Israel, for the mutual exchange of electricity from renewable sources.

- Plans for transition development in the countries on the Southern Shore present ambitious targets in terms of electricity installed capacity and overall investment. Their accomplishment seems unlikely, especially when compared the expected development of the fossil fuels infrastructure: in Algeria, 48 G$ out of the 60 G$ of investments planned for 2025-2029 will be spent on the oil and gas sectors, while Libya plans to increase its domestic production of oil and natural gas, and increase the exports of the second to Europe via the Greenstream pipeline.

The Mediterranean is a strategic hub for the energy transit and supply, with a high concentration of fossil resources on the Southern Shore and a marked energy dependence on the Northern Shore. Despite its high solar and wind power potential, the Southern Shore remains undersized in terms of installed capacity.

- The Mediterranean is a strategic hub for the transit of energy commodities. In fact, its borders are crossed by the Gibraltar and Bosphorus straits, and by the Suez Canal, through which 26.3% of the 2024 global throughput of crude oil and 20.9% of that of Liquefied Natural Gas (LNG) was shipped.
- **95% of the crude oil and 87% of the natural gas reserves of the entire Mediterranean Basin are in the Southern Shore.** Their uneven geographical distribution implies the coexistence of both net energy exporters, Algeria and Libya above all, and heavily energy-dependent countries such as Italy (81%), Spain (75%) and Türkiye (71%). In 2023, Algeria was respectively the first and ninth supplier of natural gas (26% of total imports) and crude oil (5% of total imports) for the Northern Shore and the third largest supplier of natural gas to Türkiye (12% of imports). Libya was the third largest supplier of crude oil to the Northern Shore instead, accounting for 11% of imports and preceded only by the USA (12%) and Iraq (12%).
- In 2023, exports of crude oil and natural gas from the Southern Shore countries to the rest of the Mediterranean respectively accounted for 75%, 41% and 29% of the total economic value of Algerian, Libyan and Egyptian oil and gas exports. **The economic importance of the Northern and Eastern Shore countries has historically given rise to a twofold bind among the three shores: while the first two need the energy supplies of Southern Shore exporters, these need the first to source a significant part of their incomes.**

- **In junction with the expected increase in electricity generation capacity from RES, the corresponding demand for fossil fuels in the Mediterranean Basin will gradually decline** until potentially reaching zero in 2040, at least in the most ambitious scenarios. Specifically, the demand for coal could fall from 328 kt/y in 2023 to 51 kt/y-66 kt/y in 2030, until 16.2 kt/y in 2040. The demand for oil would fall to a maximum of 4 kt/y in 2030 and 0.2 kt/y in 2040.
- **Natural gas consumption for electricity generation, on the other hand, would see a more modest reduction, at least in the entire Basin.** In fact, in the Eastern and Southern shores, its demand is expected to increase as a result of its use to replace coal and an overall increase in electricity demand. While the most ambitious scenarios for 2030 predict a drastic reduction in the Northern Shore (from 62 GSm^3/y in 2023 to a maximum of 34 GSm^3/y), the consumption is expected to increase from 68 GSm^3/y to a minimum of 89 GSm^3/y in the Southern Shore and from 26 GSm^3/y to a minimum of 34 GSm^3/y in the Eastern Shore.
- **Although the Southern Shore could harness the highest solar and wind intensities in the Mediterranean Basin, it only accounts for 1.2% of the Mediterranean electricity generation capacity from PV and wind (9 GW out of 770 GW).** The installed capacity forecasts for 2030 for the Southern Shore stand at 20 GW-35 GW for PV and 16 GW-26 GW for wind, starting from the current 4 GW and 5 GW in 2024. On the Eastern Shore, the current 27 GW of PV capacity could increase to a maximum of 43 GW, while the expected increase for wind is from 14 GW to 20 GW-28 GW.

The nuclear sector—despite having covered a significant share of electricity generation, especially in the EU—shows critical issues in the fuel supply chain (uranium ore), which is dominated by a few countries and operators. Small Modular Reactors are emerging as a possible future solution to reduce costs and enable more flexible and decentralised generation.

- **In 2024, nuclear power generation accounted for 9% of the global electricity production and for 24% in the EU.** In relation to the median yearly electricity generation, a Nuclear Power Plant (NPP) occupies an area 100 times smaller than a hydroelectric plant and 10 times smaller than a rooftop PV system.
- Among the six fission reactor technologies currently in operation, pressurised water reactors (PWRs) account for 78% of global installed capacity (294 GW out of 376 GW). **There are 65 reactors in operation in the Mediterranean Basin (71 GW**

in total), 57 of which are in France (63 GW), 7 in Spain (7 GW) and one in Slovenia (1 GW). Both in Türkiye and Egypt, a 4.8 GW NPP (featuring four 1.2 GW Russian VVER-1200 reactors) is currently under construction and is expected to start commercial activity by 2030.

- **The nuclear fuel supply chain presents several security-related issues. In fact, not only are natural uranium reserves extremely concentrated (84% is in eight countries), but 92% of the global uranium production is controlled by seven countries only, via their mining companies**. However, the main bottleneck along the nuclear fuel cycle is the provision of uranium enrichment services, as Russian state-owned company TVEL alone holds 40% of the world's industrial capacity.
- **Small Modular Reactors (SMRs) are an emerging fission reactor technology consisting of units no larger than 300 MW,** which could be mounted in modular configurations and mass-produced, thus reducing the high upfront costs characterizing traditional large-scale power plants. **They represent a potential solution for decentralised electricity generation** – especially in geographically remote areas – and the repurposing of decommissioned coal-fired power plants. Currently, **there are only five SMRs in operation (two in both China and Russia, the fifth in Japan)**, while about 100 other designs are under development and/or undergoing a licensing process.
- Two more NPP are scheduled for construction in **Türkiye** by 2035. **French nuclear capacity expansion plans** include the installation of 10 GW of nuclear reactors, with the possibility of adding further 13 GW. In **Slovenia**, there are plans to build a second large-scale power plant, but the timeline of the project is more uncertain. **In 2030, the demand for nuclear fuel required to meet the consumption of NPP in the Mediterranean countries is estimated at 10 MtU, corresponding to 13%-15% of the expected global demand.**

The reserves and the production supply chains of Critical Raw Materials are concentrated in a few extra-Mediterranean countries, increasing risks of supplying security for the Med Countries. The heavy dependence on imports exposes the Mediterranean Basin to geopolitical vulnerabilities and to a deterioration of the trade balance.

- **The transition towards the electrification of the energy system will likely lead to a substantial increase in the demand for Critical Raw Materials (CRMs)**, needed to manufacture several among the technologies used for the generation, transport, conversion and final consumption of electricity. **Such growth will give rise to new**

security-related issues, as both their reserves and extraction/processing capacities are concentrated in few countries, while almost non-existent in the Mediterranean Basin.

- **The CRMs market is dominated by China, which leads the production of several among them, often with near-monopolistic market shares too. Such is the case, for example, of REEs (71%), tungsten (76%), graphite (67%), magnesium (64%) and vanadium (68%). The DRC controls 70% of the global cobalt production and Brazil 93% of that of niobium.** In the Mediterranean, Türkiye is the world's leading producer of feldspars with a 40% share, whereas although Morocco has the largest reserves of phosphates (68% of the world's total), its leading producer remains China with a 44% share.
- **The dependence of Mediterranean countries on the imports of CRMs not only risks introducing new dependency ties but will even worsen their trade balance.** In fact, in 2023, the import/export of CRMs from/to extra-Mediterranean countries had already generated an economic deficit of more than 28 G$ and even 37 G$ in 2022. **The expected increase in the demand for CRMs by 2030-2035** will inevitably exacerbate the situation, **making supply chains even more vulnerable and sensitive to perturbations and/or supply disruptions.**
- The global production of CRMs employed to manufacture transition technologies in 2030 should be large enough to match the corresponding demand calculated for the Mediterranean Basin. Nevertheless, Mediterranean countries will still be exposed to the severe risks inherent to supply disruptions and their consequent price volatility effects. **In 2024, the European Commission published the *Critical Raw Materials Act*, in which it encourages Member States to satisfy the EU's demand for CRMs ensuring at least 10%, 40% and 25% respectively comes from domestic extraction, processing and recycling.**

Thanks to the use of quantitative indicators to assess the Energy Trilemma in the Mediterranean Basin, significant vulnerabilities emerge related to the import of Critical Raw Materials and energy fuels. *The New Pact for the Mediterranean*—together with all European policies aimed at strengthening energy security in the Med Area—seeks to enhance collaboration and cooperation among the three shores.

- **The report presened a set of numerical indicators conceived to summarise the three attributes of the Energy Trilemma – environmental sustainability, energy**

security and affordability – with due attention to security. The adoption of indicators to quantify the evolution of energy systems is fundamental in the context of policy decision-making, as it provides decision-makers with an intuitive and concise tool on which to base their strategic planning choices.

- The carbon intensity of the 2030 Mediterranean electricity generation mix could range between 142 gCO_2/kWh and 181 gCO_2/kWh, although with significant differences between the three shores: in the Northern Shore, it will vary between 40 gCO_2/kWh and 70 gCO_2/kWh, thanks to the wider employment of RES electricity generators. In contrast, in the Southern Shore, the generation mix will still be heavily reliant on fossil fuels, as underscored by the carbon intensity of the two main oil and natural gas producers, Algeria (354 gCO_2/kWh-375 gCO_2/kWh) and Libya (351 gCO_2/kWh-369 gCO_2/kWh).
- **The security of supply of CRMs is quantified using two indicators**: the Supply Risk (SR) and the Economic Importance (EI) – **higher values imply greater difficulty in compensating for supply disruptions and/or finding adequate substitute materials**. Most REEs, of which China is an almost monopolistic producer, have both high SR and EI values, as in the cases of dysprosium (SR: 5.6, EI: 7.8), neodymium (SR: 4.5, EI: 7.2), samarium (SR: 3.5, EI: 7.7) and terbium (SR: 4.9, EI: 6.4).
- **The EU is totally dependent on imports from extra-EU trading partners to match its internal demand for most CRMs.** This is the case, for example, of antimony, boron, **lithium**, **magnesium**, niobium, phosphates, **titanium and REEs**. In the *Critical Raw Materials Act*, the Commission calls on Member States to ensure that no more than 65% of imports of a specific material come from a single supplier.
- **The security of crude oil and natural gas supplies depends on the composition of their import mix on the one hand, and on the intrinsic security of supply corridors on the other.** The diversification of import mixes in the Northern and Eastern shores has drastically increased: in the period 2003-2023, the Shannon Index for natural gas imports rose from 0.45 to 0.64 and from 0.39 to 0.62, respectively. The security of supply corridors is directly linked to the geopolitical stability of the countries they stretch through and, in the case of maritime routes, especially to the presence of chokepoints. This is relevant for the Mediterranean Basin, whose borders are crossed by the Straits of Gibraltar and the Bosphorus, and the Suez Canal.
- **Strategies and policy frameworks devoted to strengthening energy security in the Mediterranean Basin have increasingly proposed collaboration and cooperation between the shores and envisaged the wide adoption of RES, more sustainable economic models and to limit the environmental impact of energy systems.** This

commitment has been recently confirmed in the *New Pact for the Mediterranean*, issued by the European Commission in October 2025. Among its objectives, the Pact includes the creation of new job vacancies and ad-hoc training programmes, the construction of new energy and digital infrastructures, and the strengthening of the internal security in the area.

The energy transition is reshaping global demand for critical raw materials. High market concentration increases the vulnerability of supply chains.

- The spread of renewable energy sources and green technologies has led in recent years to a significant increase in demand for all the raw materials. **Copper, cobalt, nickel, lithium, graphite, REEs are essentials for electric vehicles, battery storage, renewables and grid networks.**
- The IEA and UNCTAD emphasize that **demand for energy transition minerals is expected to nearly triple by 2030 and more than quadruple by 2040**, with particularly steep growth anticipated in 2025–2035.
- **Lithium** demand (whose use is essential for electric vehicles) **rose by nearly 30% in 2024**. Demand for **nickel, cobalt, graphite and rare earths increased by 6-8%** in 2024.
- Between 2020 and 2024, some 90% of **supply growth in refined critical material production** came from the top single supplier alone: Indonesia for nickel and China for cobalt, graphite and rare earths.
- This concentration increases the risk of supply shocks, with potential effects on prices, industrial competitiveness and energy security.

Seaborne trade thus serves as the backbone of mineral value chains. The flows of these sea-traded raw materials show a long-term structural growth.

- Most of the flows of these critical materials (raw, semi-processed and refined) are traded by sea. **Seaborne trade thus serves as the backbone of mineral value chains, connecting resource-rich economies with global refining hubs and end users.**
- Critical minerals such as iron ore, copper and zinc are transported primarily **via bulk carriers** (the trade of these raw materials falls specifically within **the *minor bulk* category**), while processed minerals, high-value cargo and materials

requiring enhanced security or traceability – such as lithium compounds – are increasingly shipped in containers.

- World seaborne minor bulk trade grew by 29% between 2012 and 2025 (minor bulks include four macro categories: agribulks (i.e. sugar, rice, fertilisers), minerals - i.e. cement, coke, sand -, manufacturers - i.e. steel products, forest products - and **metals in which we find some critical materials such as bauxite, nickel, manganese and copper**. Among minor bulk goods metals have grown the most in recent years. Between 2017 and 2025, metals saw a 46% increase in their maritime trade.
- Critical minerals shipments experienced strong long-term growth between 2000 and 2025. **Maritime trade in nickel ore** (used in batteries and as a key component in alloys such as stainless steel used in the automotive industry) **has increased tenfold**. The figure for **bauxite** (the main source for aluminium production) is now around **eight times that of 2000**. There has also been significant growth for **manganese ore** (used in batteries and as a key element in special steels, reaching a value **five times that of 2000**) and **copper** (the cornerstone of all electricity-related technologies, **+294%**).
- Seaborne trade in **nickel ore** experienced the **most pronounced expansion**, particularly **after 2010**. **Bauxite** trade began **rising more sharply from 2015 onward,** linked to the spread of green technologies.

Trade routes are highly concentrated and strategic. Copper and cobalt exhibit highly polarized value chains.

- Among the importing countries, **China takes the lion's share for bauxite, nickel, manganese, copper and cobalt**
- Over 90% of sea traded **bauxite** is **exported by** just two countries: **Guinea (74%) and Australia** (18%). **89% of the total is shipped to China**. **84% of seaborne Nickel Ore** is **exported from the Philippines**, while **55% of seaborne Manganese Ore is exported from South Africa**.
- For **copper**, flows from Chile and Peru to China dominate seaborne trade. **The top 5 exporters account for 55.3%** of the global seaborne copper trade across all stages.
- For **cobalt**, the Democratic Republic of the Congo supplies over 80% of global exports, largely directed to China. **The top 5 exporters account for 88%** of the global seaborne volume trade across all stages. **Midstream hubs** such as **Belgium**

and Finland also **play a role, refining and re-exporting cobalt to major industrial consumers.**

- **Raw copper still flows primarily** from major producers such as Chile, Peru and Indonesia to China. Semi-processed and manufactured copper plays a minor role.
- The seaborne trade of **cobalt** witnessed a shift in composition **around 2015**: **the trade of semi-processed cobalt increased steadily**, driven by several reinforcing factors, among which the policy support for in-country benefits in major producing nations and the international investment in local refining infrastructure, especially with Chinese support.

The trade in critical minerals has become a focal point of strategic geopolitics. Control over the various stages of processing is at the heart of industrial plans and new geopolitical designs.

- **Importing countries** are implementing legislative initiatives, often accompanied by strategic partnerships and bilateral cooperation frameworks, **aimed at reducing excessive dependence on highly concentrated suppliers.**
- **Exporting developing countries** are **increasingly adopting measures to retain a greater share of the value generated by their strategic mineral resources.**
- Raw minerals still dominate maritime flows, but semi-processed are growing. **Control of refining is the real competitive advantage.**
- **China has not only mining capacity, but above all refining and intermediate** processing capacity. This country also stands out as the main refiner for cobalt with 78% of the market.
- While many advanced economies are aiming to relocate chip or battery production, they remain dependent on inputs that come almost exclusively from China. **Whoever controls critical minerals controls the material basis of technological transition.**

While energy security requires new long-term strategies, maritime logistics can play its part in integrating the supply chains of critical raw materials.

- **Traditional energy risks affecting the security of oil and gas supply** are **now accompanied by vulnerabilities in other areas, most visibly in supply chains for critical minerals**, which face high levels of market concentration.
- **Some pathways on which the developed and developing economies should act for a future energy security context:**
  - **Supply diversification.** Partnerships and agreements between countries for the development of local mining projects and industrial capacity;
  - **Recycling to fill the supply gap.** For example, the supply of recycled cobalt accounted for 12% of demand in 2024;
  - **Improving port infrastructure efficiency and logistics connectivity.** To enhance the capacity of developing countries to move beyond the export of raw materials by increasing domestic processing, promoting their industrial upgrading.