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Ministry of Foreign Affairs of the Republic of Azerbaijan

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Renewable Energy Sources and Energy Security in SE Europe

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INSTITUTE OF ENERGY
FOR SOUTH EAST EUROPE

Presentation Outline

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2. Introductory Remarks
3. SE Europe's Energy Mix
4. SE Europe's Power Generation Mix
5. The Role of RES in Energy Security
6. Decarbonisation in SE Europe: RES is not Enough
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11. Energy Trends in SE Europe – a Scenario Approach
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The SE European Region as Defined by IENE

Core countries

- Albania
- Bosnia and Herzegovina
- Bulgaria
- Croatia
- Cyprus
- Greece
- Hungary
- Israel
- Kosovo
- Montenegro
- North Macedonia
- Romania
- Serbia
- Slovenia
- Turkey

Peripheral countries

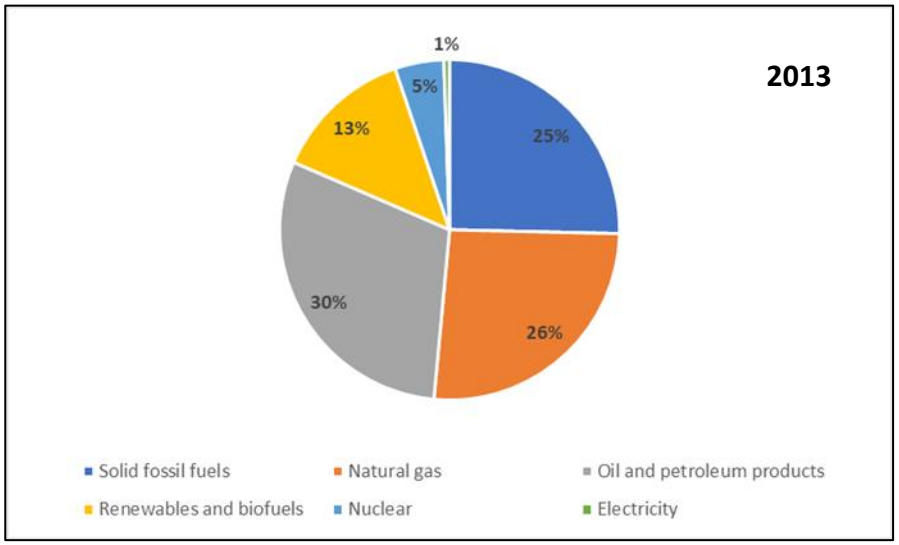
- Austria
- Egypt
- Italy
- Lebanon
- Moldova
- Slovakia
- Syria
- Ukraine

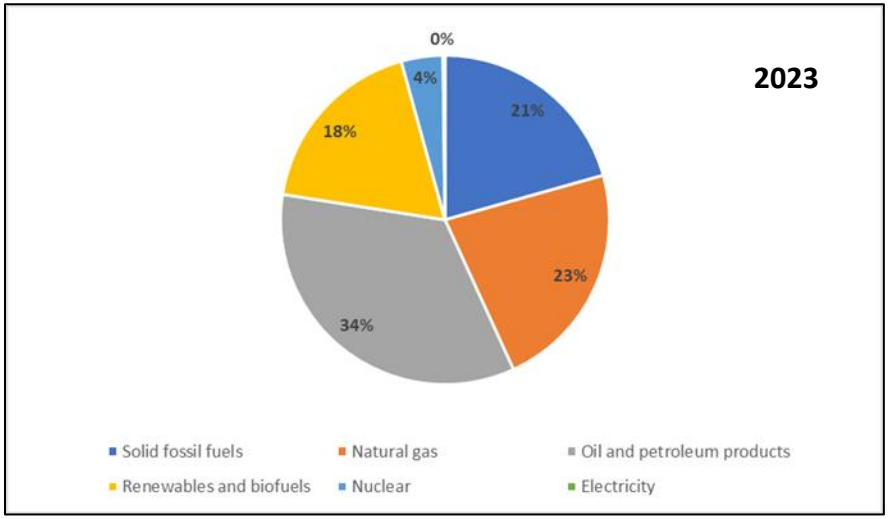
Source: IENE

Introductory Remarks (I)

- As our part of the world is caught in the grip of a major geopolitical crisis - the war in Ukraine and the Israel-Middle East conflict and their broader implications - the strategic importance of SE Europe has become more relevant.
- With the various conflicts in the wider geographic area, surrounding our core country group, having intensified over the last few months, the issues related to energy security have gained prominence, and today are at the forefront in the debate concerning the revision of energy policies.
- These issues involve both the supply of basic energy commodities and products, including oil and gas, but also the use of energy through electricity and gas grids.
- The EU and several (but not all) governments in the broader SEE area regard renewable energy sources as vital for strengthening energy security, especially since their use helps with the decarbonisation of the energy system.
- With energy markets becoming more and more interdependent, as the almost daily cross border energy flows clearly show, it is important to understand the structure and functioning of the energy sector on a regional basis. Hence, our Institute's regional approach.
- Although the region has supposedly entered a decarbonisation mode, in line with EU's energy transition targets, there is only small differentiation of the overall energy mix over the last 15 years or so.
- Looking at the energy mix (including Türkiye), we observe that contribution of solid fuels has dropped slightly by 4.0%, natural gas has also less participation by 3.0%, oil petroleum products have in fact increased their participation by 4.0%, RES have increased their input by 5.0%, nuclear is contributing 1.0% less and electricity (thanks to increased cross border trade) has decreased its presence by 1.0%.
- Overall, fossil fuels have decreased their participation in the regional energy mix (including Türkiye) only by 4.0% in ten years, from 2013 to 2023 (from 25% to 21%).
- Natural gas has become a strategic fuel in the energy transition process and once again is critical for the operation of the energy systems in SE Europe.

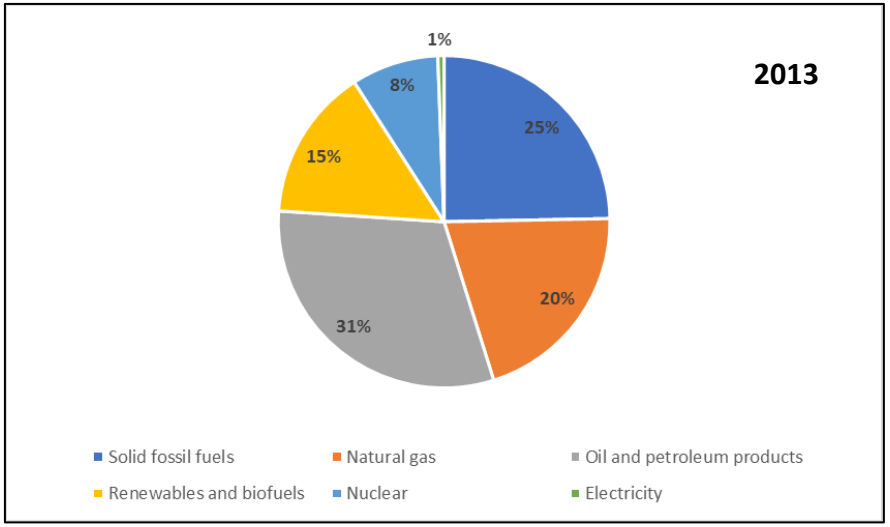
SE Europe's Energy Mix, Including Türkiye**, 2013 and 2023**

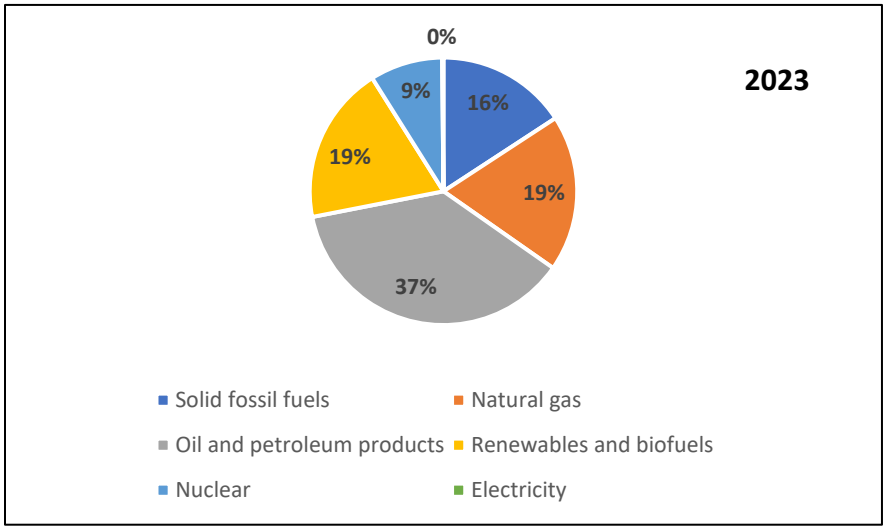




Sources: Eurostat, IENE

SE Europe's Energy Mix, Without Türkiye, 2013 and 2023



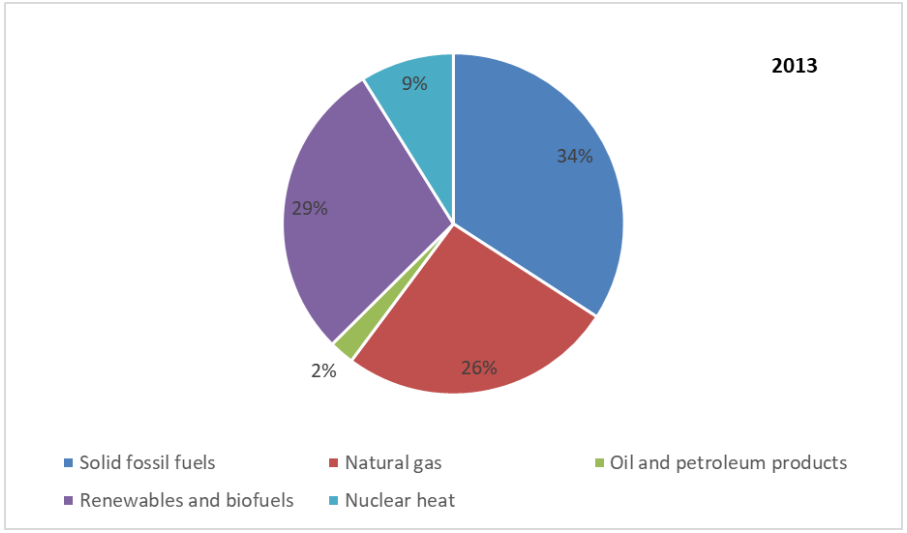


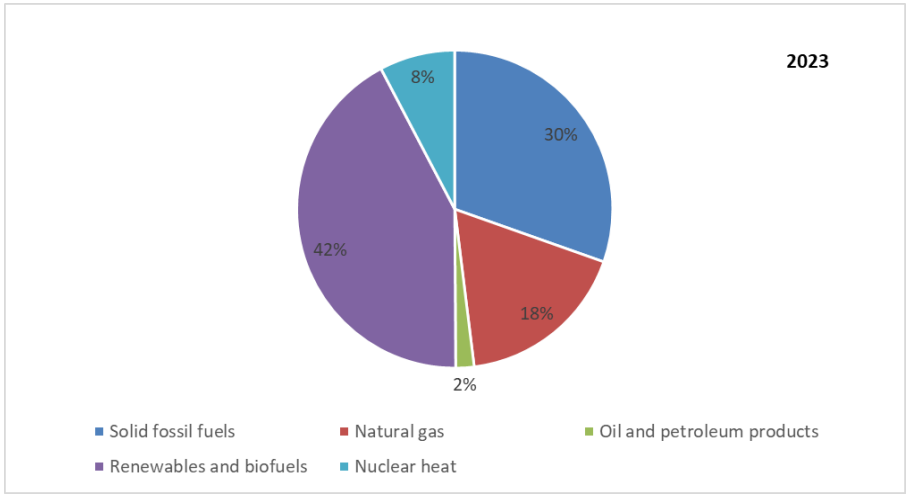
Sources: Eurostat, IENE

Introductory Remarks (II)

- As energy transition to cleaner fuels has come to dominate strategic choices over the last years, it is important to see the impact of such strategies in the region.
- In contrast to the overall energy mix (including Türkiye), there is much greater change in power generation (including Türkiye), as solid fuels have decreased their input by 4.0%, gas has declined its share by 8.0%, oil products have remained stable at 2.0%, nuclear has lost share by 1.0% and Renewables are the clear winners as they have increased their share by 13.0% corresponding to 42.0% of power generation.
- A number of countries are leading SE Europe in this electricity transformation and these include Türkiye, Romania, Greece and Bulgaria. Admittedly, there is growing interest now from most countries in the region, including Serbia, for a much faster penetration of RES in their power generation mix and the whole scene could be a lot different by 2030.
- As RES penetration is growing in all countries in the region, a number of problems are surfacing, including curtailment of RES generated electricity, due to a mismatch of demand and supply, lack of storage and poorly managed electricity grids which need serious upgrading and the introduction of modern load management tools, including power electronics.
- A general observation at this stage is that although the power generation mix of the region is changing fast the overall energy mix, i.e. primary energy production and final energy consumption, is changing very slowly at an almost glacial pace. This is unlikely to change any time soon as the system's demand characteristics are not affected that easily - largely dominated by energy demand for transportation, industry and buildings (see IENE's energy demand scenarios further down the presentation).
- Obtaining and improving energy security, which will remain a prime concern for all countries in the region, will depend on the rational management of existing and future resources, the securing of base load systems, the wide use of energy efficiency and the attainment of an optimum balance between conventional and new/clean energy sources.

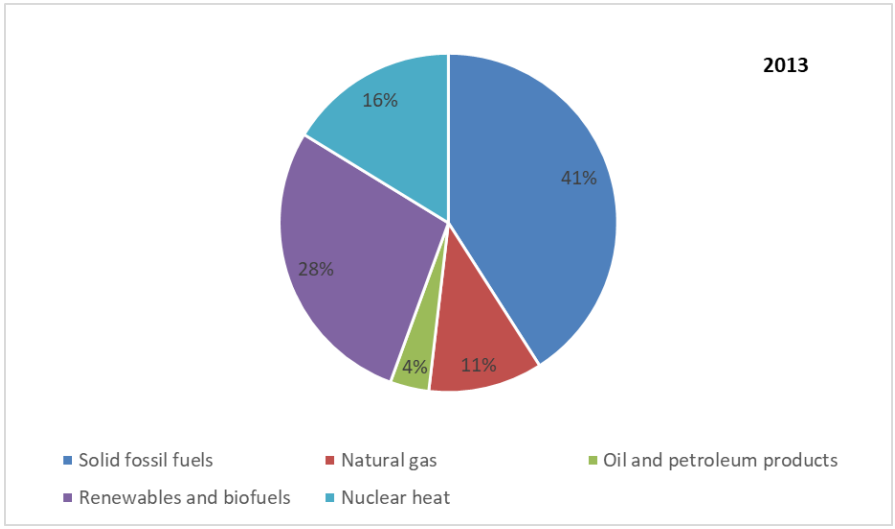
SE Europe's Power Generation Mix, Including Türkiye, 2013 and 2023

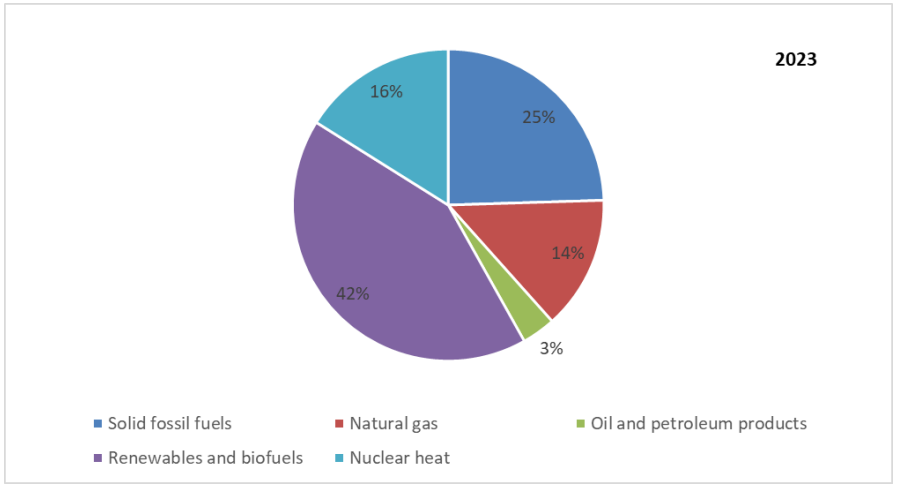




Sources: Eurostat, IENE

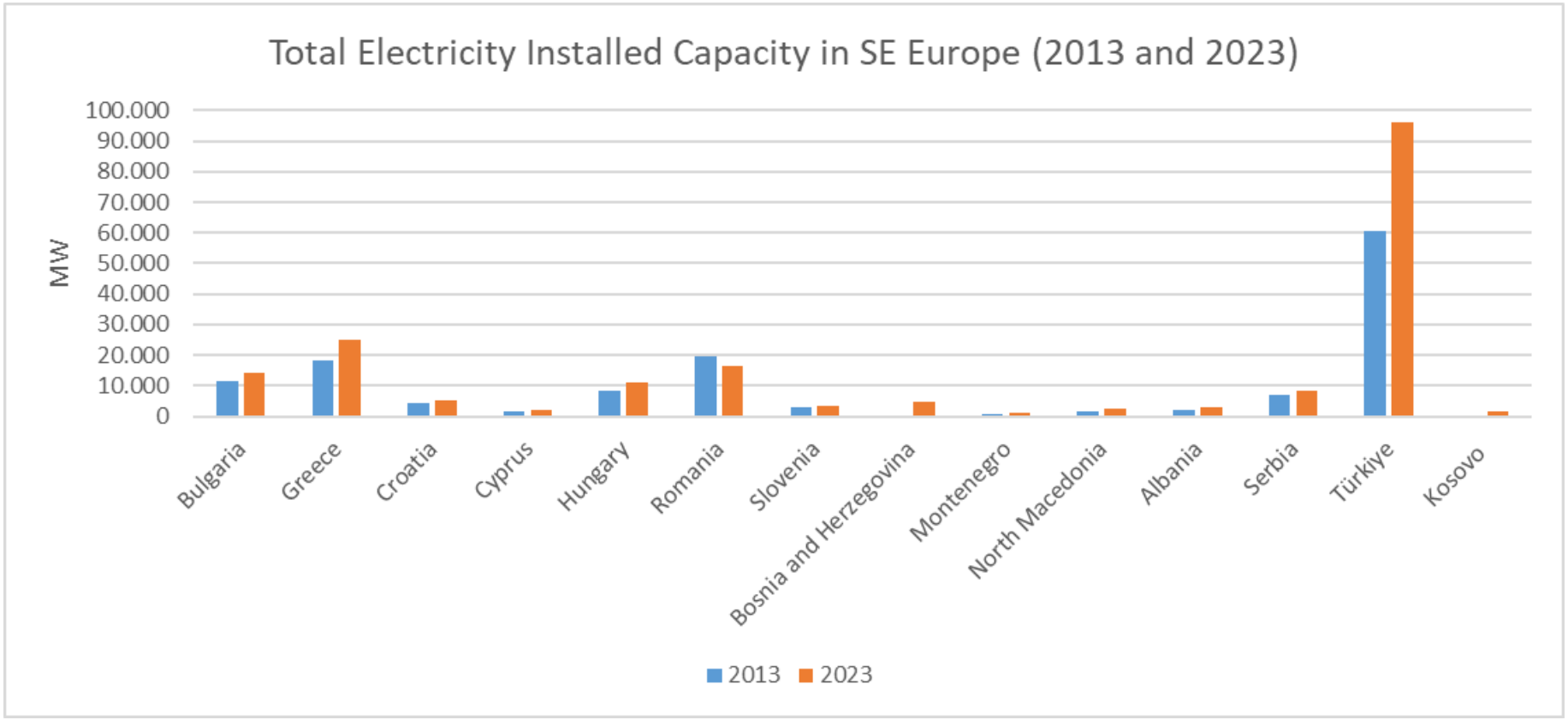
SE Europe's Power Generation Mix, Without Türkiye, **2013 and 2023**





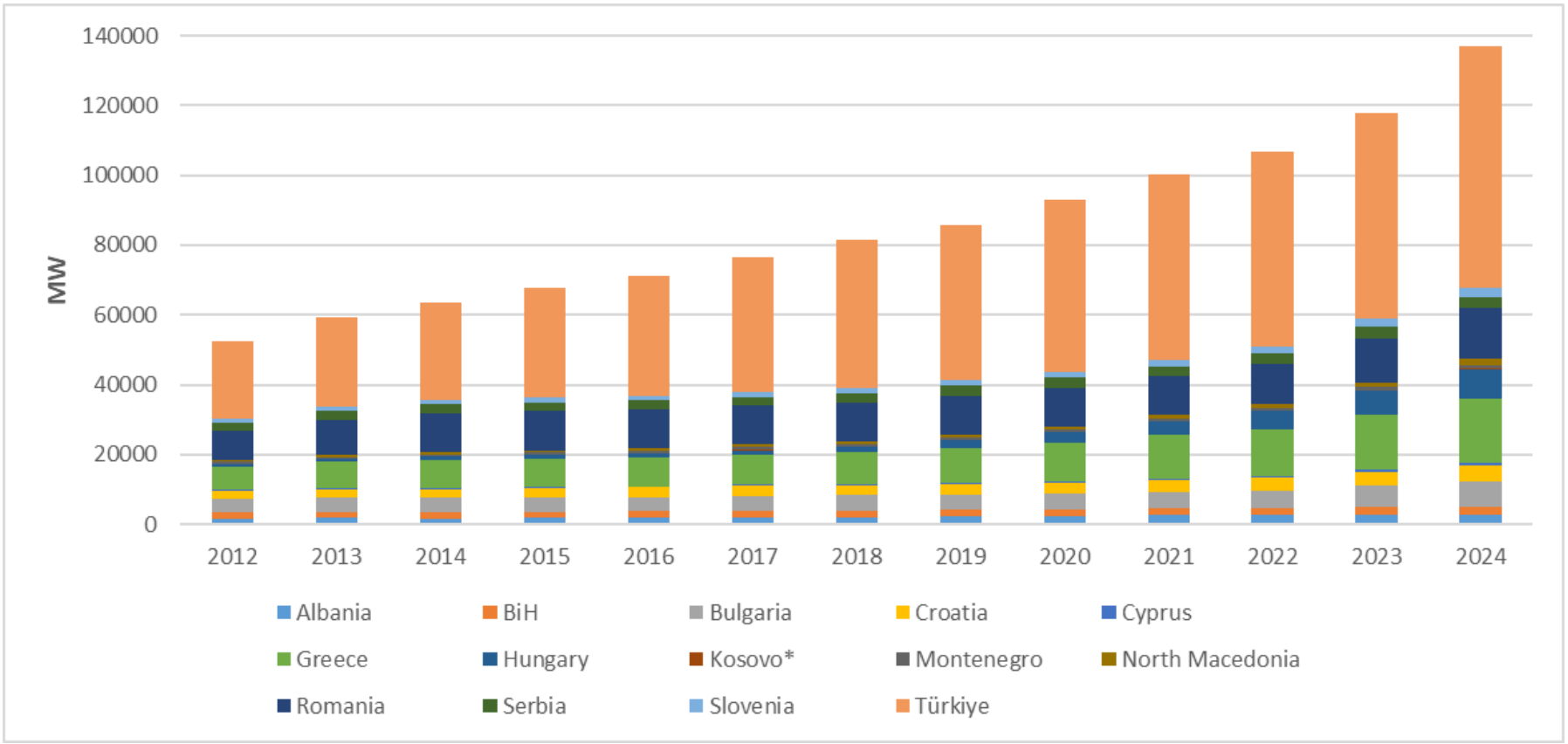
Sources: Eurostat, IENE

Total Electricity Installed Capacity in SE Europe, 2013 and 2023



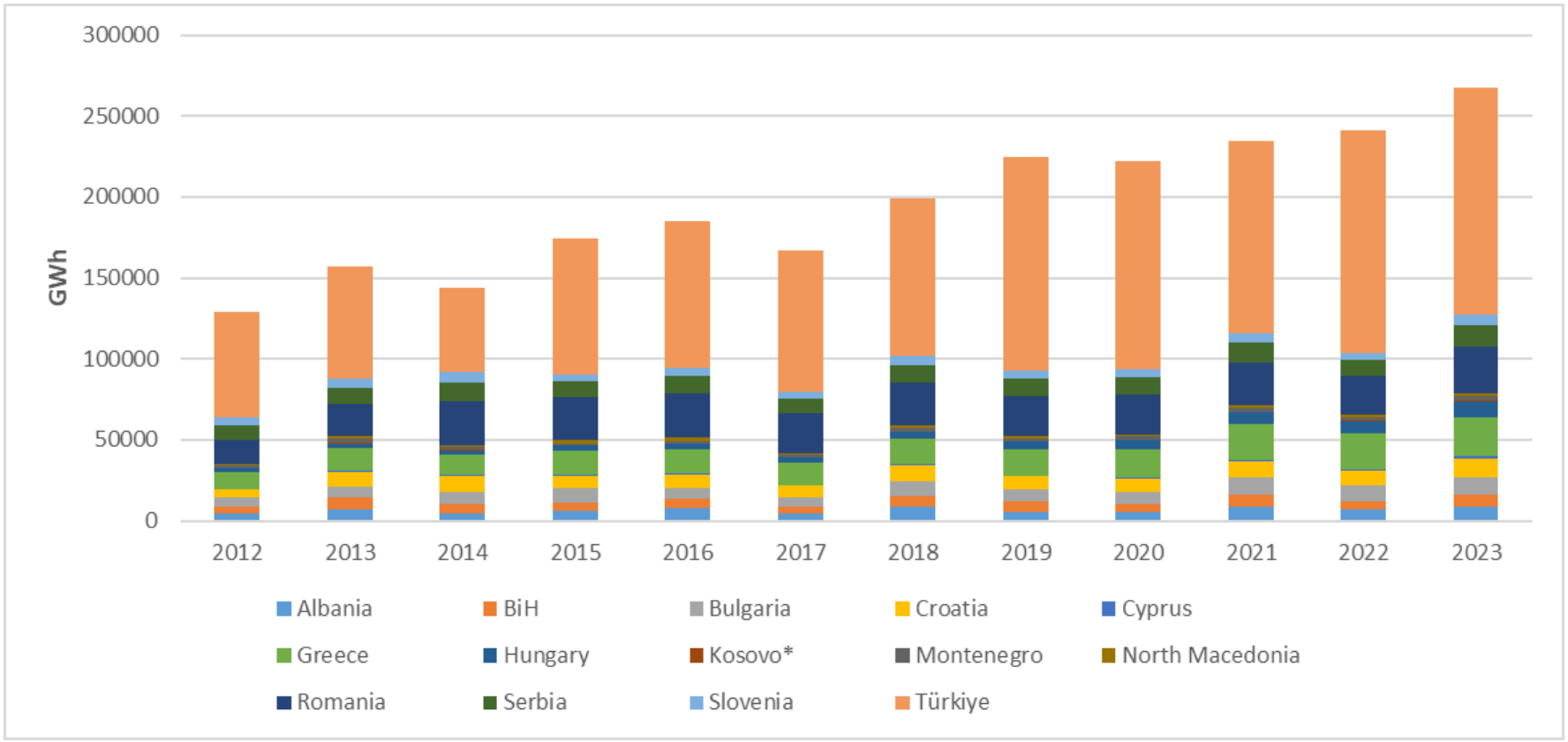
Sources: Eurostat, IENE

Total Installed RES Capacity (MW) by Country in SE Europe, 2012-2024



Source: IRENA

Renewable Electricity Generation (GWh) in SE Europe, 2012-2023

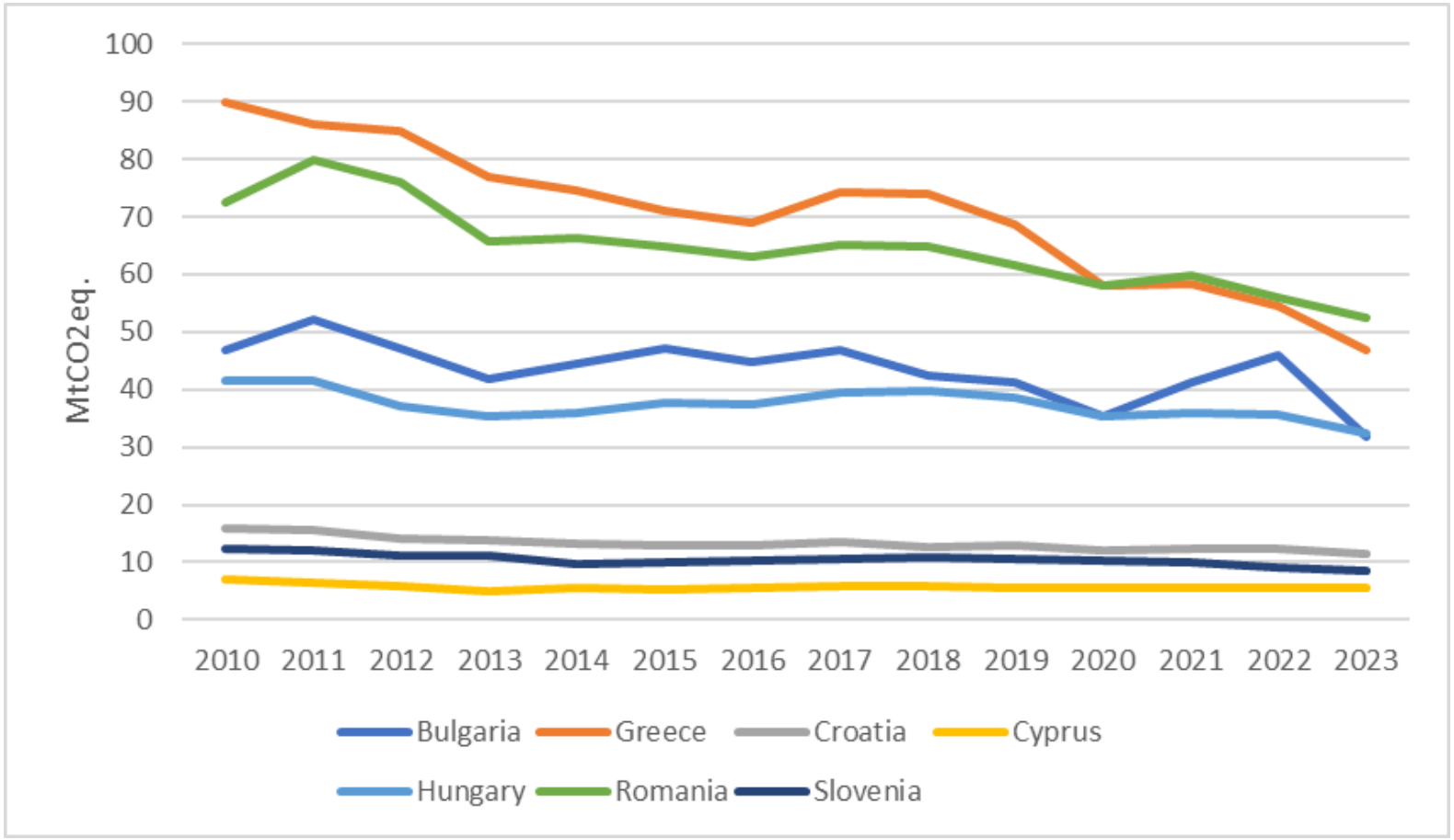


Source: IRENA

What is the Impact From the Increased Penetration of RES in the Electricity Mix

- Over the last 15 years or so, we have seen a significant rise in the installed capacity of RES installations in almost all countries in the region.
- From less than 45 GW in 2010, these have now reached near 125 GW with corresponding high electricity generation outputs.
- Some countries, especially Greece (50%), Romania (35%), Bulgaria (17%) and Türkiye (41%), already cover a substantial part of their electricity mix with Renewables.
- However, the rapid rise of RES share has led to serious curtailments in some countries of RES input into the electricity grid, which TSOs re-obliged to implement in order to safeguard the stability of the system.
- Also, the much-increased share of RES in the electricity mix has not resulted in substantial CO2 reductions, as latest figures show. This is understandable since electricity still corresponds to a small share of the overall gross or final energy use.
- Furthermore, and contrary to popular belief, the increased use of RES has not led to much-reduced electricity prices which are determined by the Target Model and which continue to fluctuate widely very much depending on gas prices and CO2 emission costs.

CO2 Emissions from Energy Activities in Selected SE European Countries, 2010-2023

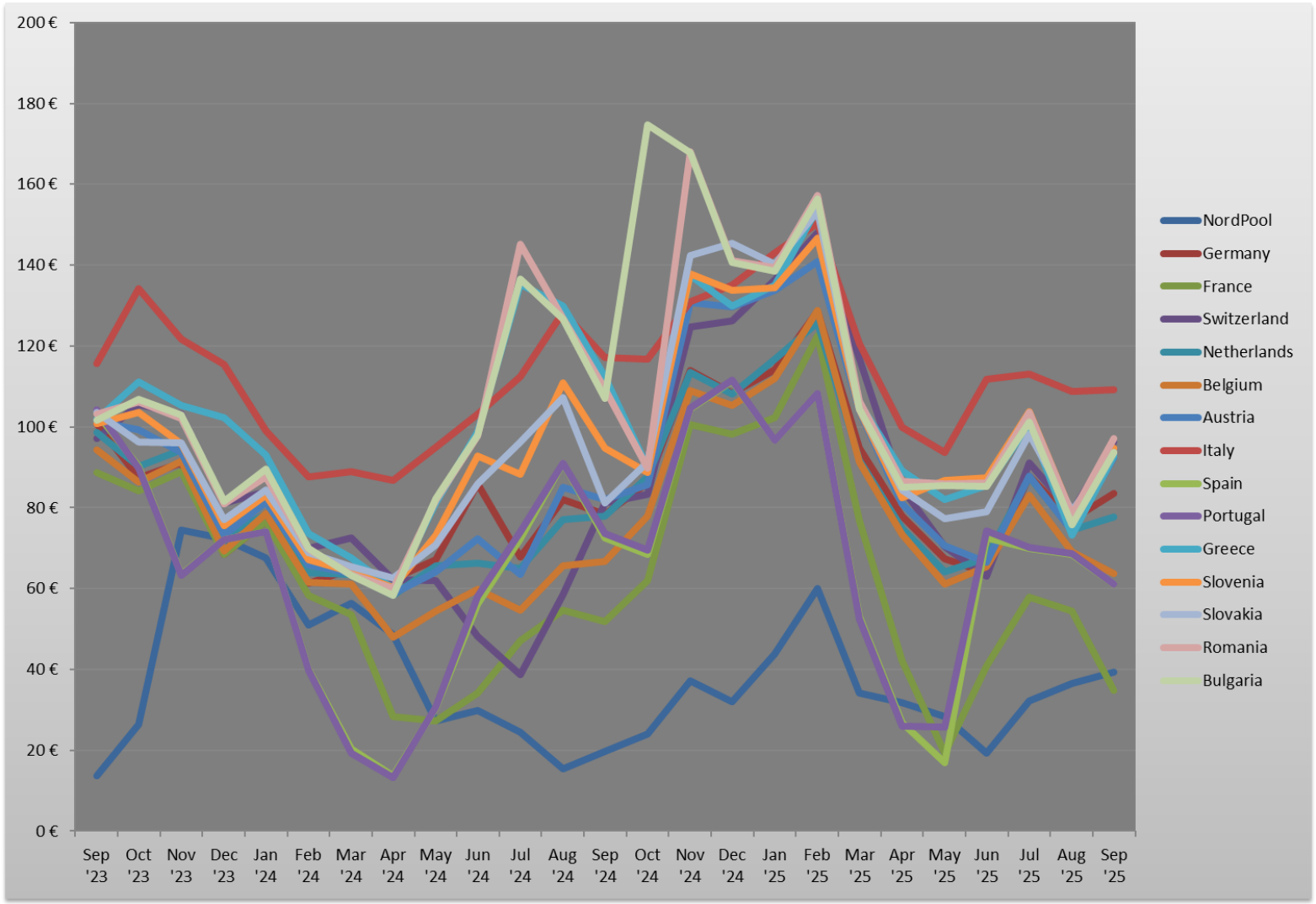


Source: Eurostat

Electricity Prices in SE Europe

- Over the last few years, electricity prices in SE Europe have become increasingly volatile, a trend largely driven by the rapid expansion of renewable energy sources. Historically, the region relied on a mix of coal, gas, and hydropower, which offered relatively predictable pricing.
- However, the surge in solar and wind installations—especially in countries like Greece, Bulgaria, and Romania—has introduced new dynamics. While renewables offer low operating costs and environmental benefits, their intermittent nature means supply can fluctuate dramatically, especially during periods of low sun or wind.
- This variability has exposed structural weaknesses in SE Europe's energy systems. Most countries lack sufficient energy storage and flexible backup generation, making it difficult to balance supply and demand in real time. When renewable output is high, electricity prices can plummet—even turning negative—due to the merit-order effect. But when output drops unexpectedly, prices can spike as expensive fossil-fuel plants are called in to fill the gap.
- These swings are amplified by limited regional grid integration and underdeveloped intraday markets, which struggle to respond quickly to changing conditions. To stabilize prices and support the energy transition, Southeast Europe must invest in grid flexibility, cross-border cooperation, and diversified renewable portfolios.
- Expanding wind capacity, developing battery storage, and improving forecasting tools can help smooth out fluctuations. Regional initiatives like CESEC are working to enhance market integration and infrastructure, but progress remains uneven. Without coordinated action, the volatility caused by renewables—though a sign of progress—could undermine public trust and slow the shift toward a cleaner, more resilient energy future.

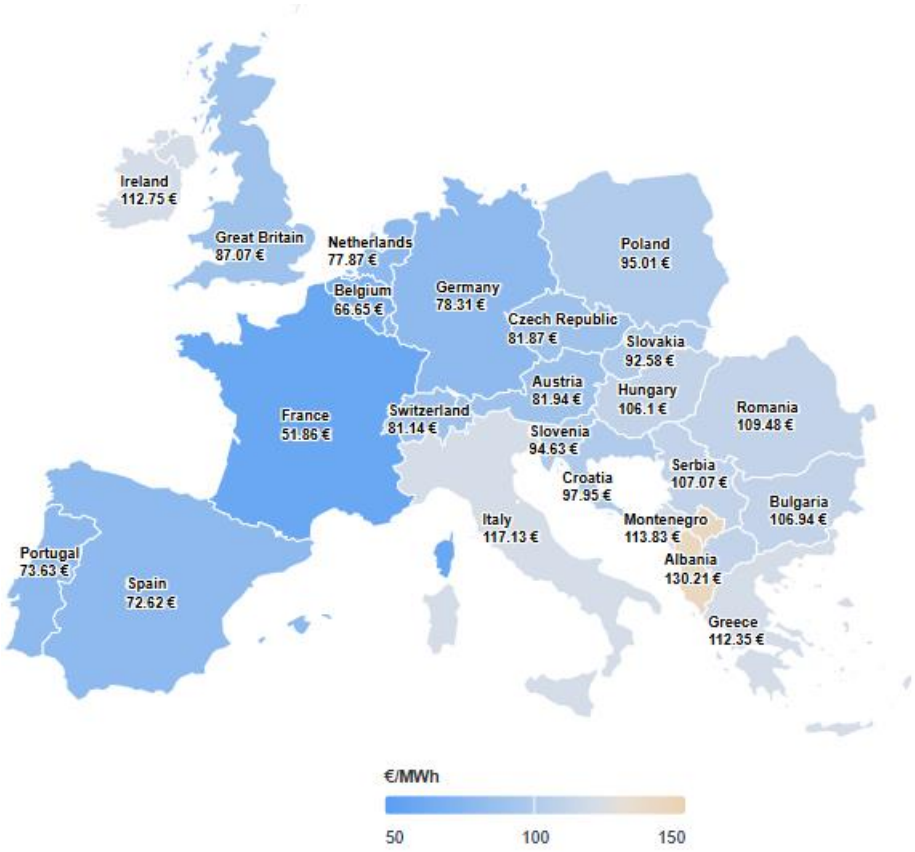
Variation of European Wholesale Electricity Prices (September 2023 – September 2025)



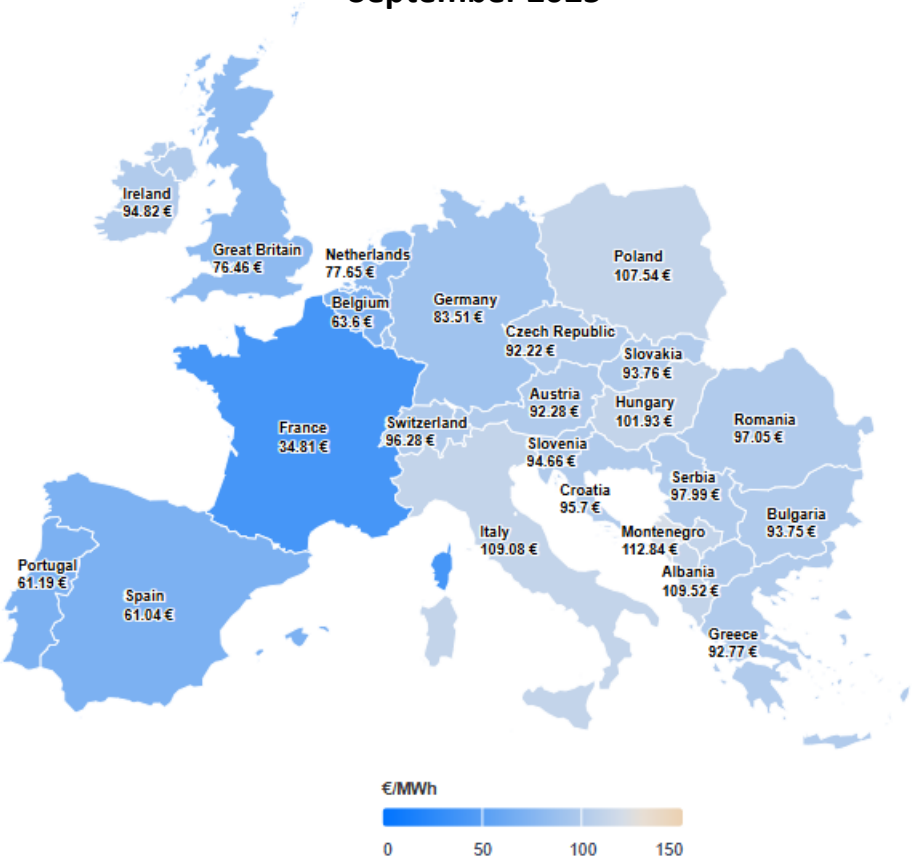
Source: Data from power exchanges websites

European Wholesale DAM Electricity Prices (September 2024 and September 2025)

September 2024



September 2025



Source: Energy Live

The Importance of Electricity Grids

- As we move towards greater RES penetration, we are also moving towards greater electrification
- Greater electrification means (which happens gradually) more expanded electricity grids.
- More expanded electricity grids means technological upgrading to allow more efficient management of electricity flows
- Technological upgrading means constant attention to grid requirements and consumer trends and the need for versatility in design, procurement and installation of infrastructure (i.e. power electronics, smart meters, software, interfaces, etc.)
- All these bring us to the realisation of a totally new operational environment for consumers, transmission operators and autoproducers alike.
- An environment which is already shaping right now as we talk and will soon come to dominate the energy scene.
- Hence, the need for consumer and producer adaptation is paramount.
- As far as our geographical area is concerned in SEE, there are great discrepancies between countries with some more advanced than others.
- Accelerated electrification, which is the objective in order to accommodate more inputs from a multitude of autoproducers, poses certain key challenges, which range from security of energy supply to management and funding issues.

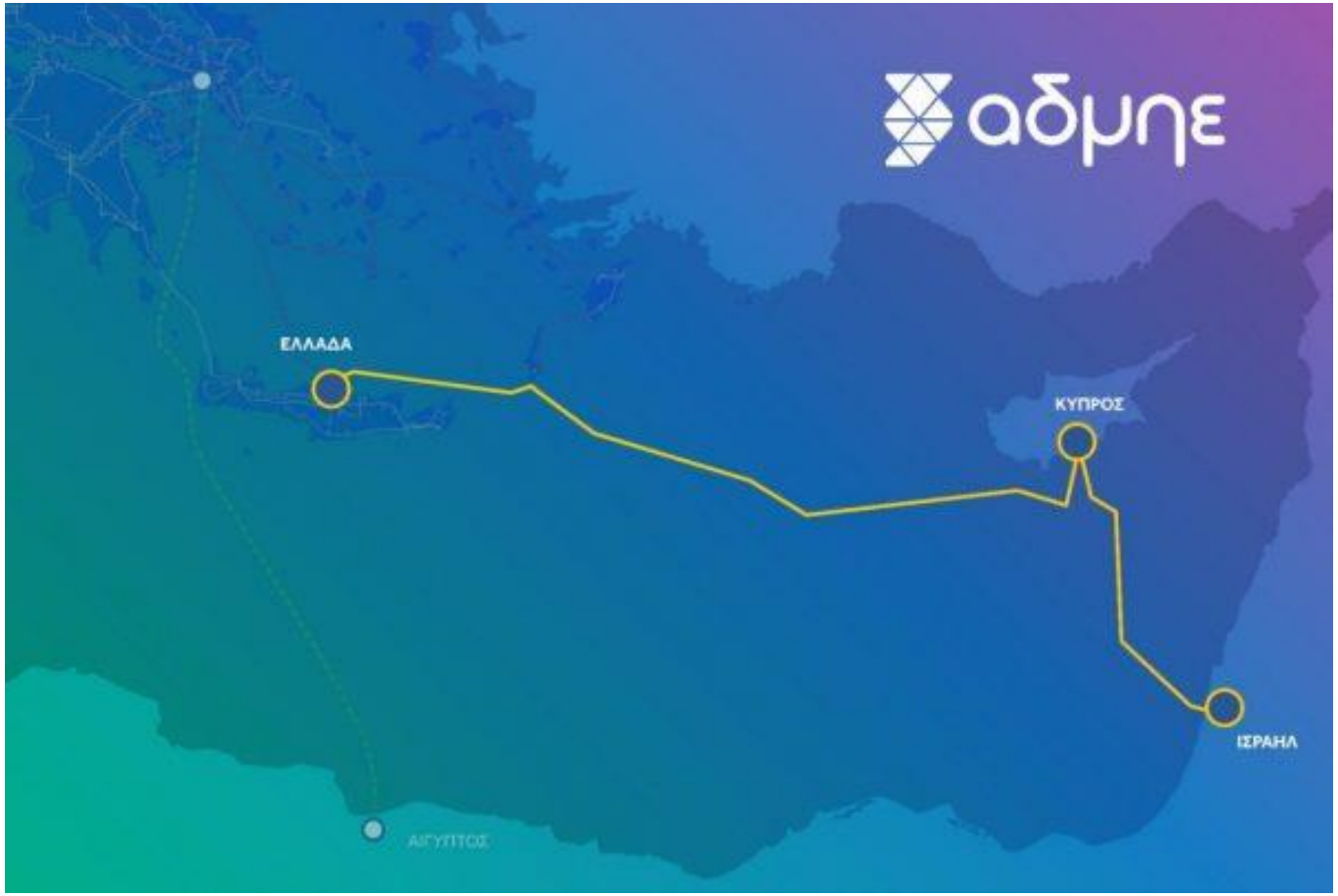
The State of Electricity Grids in SE Europe

- The SEE region is in need of more and better electricity interconnections, something which is especially visible in island regions, such as Greece and Cyprus.
- Advancing international electricity interconnections, especially between Italy and Western Balkans and between mainland Greece and the Israel-Cyprus-Crete axis, is becoming a priority in view of the fast-advancing electricity market integration in the region.
- Of great significance are the developments regarding the electricity interconnections of the islands with the power grid in mainland Greece, and improved cross-border interconnections that will enable the national electricity transmission system to cover the requirements of the new targets for RES penetration and the incorporation of energy storage systems by 2030.
- Currently, planned projects for cross-border electricity infrastructure in SE Europe are critical both to prevent market congestion and to enable the integration of electricity from RES, but their impact is more clearly visible after 2030.
- The promotion of the use of hybrid stations with RES, i.e. RES and storage, is another solution in cases where the electricity interconnection of the islands is not economically viable, but such stations will have to be assessed as to technical and economic factors and compared to the existing situation, and their installation and operation can be promoted only if it is ensured that power generation costs are reduced in total in the autonomous system involved each time and as compared to other mature solutions.
- The so-called peripheral countries are playing an increasingly more influential role in the channeling of energy flows into the SEE region. Hence, there is a continuous need for the upgrading of international electricity interconnections.

Electricity Interconnections in SE Europe

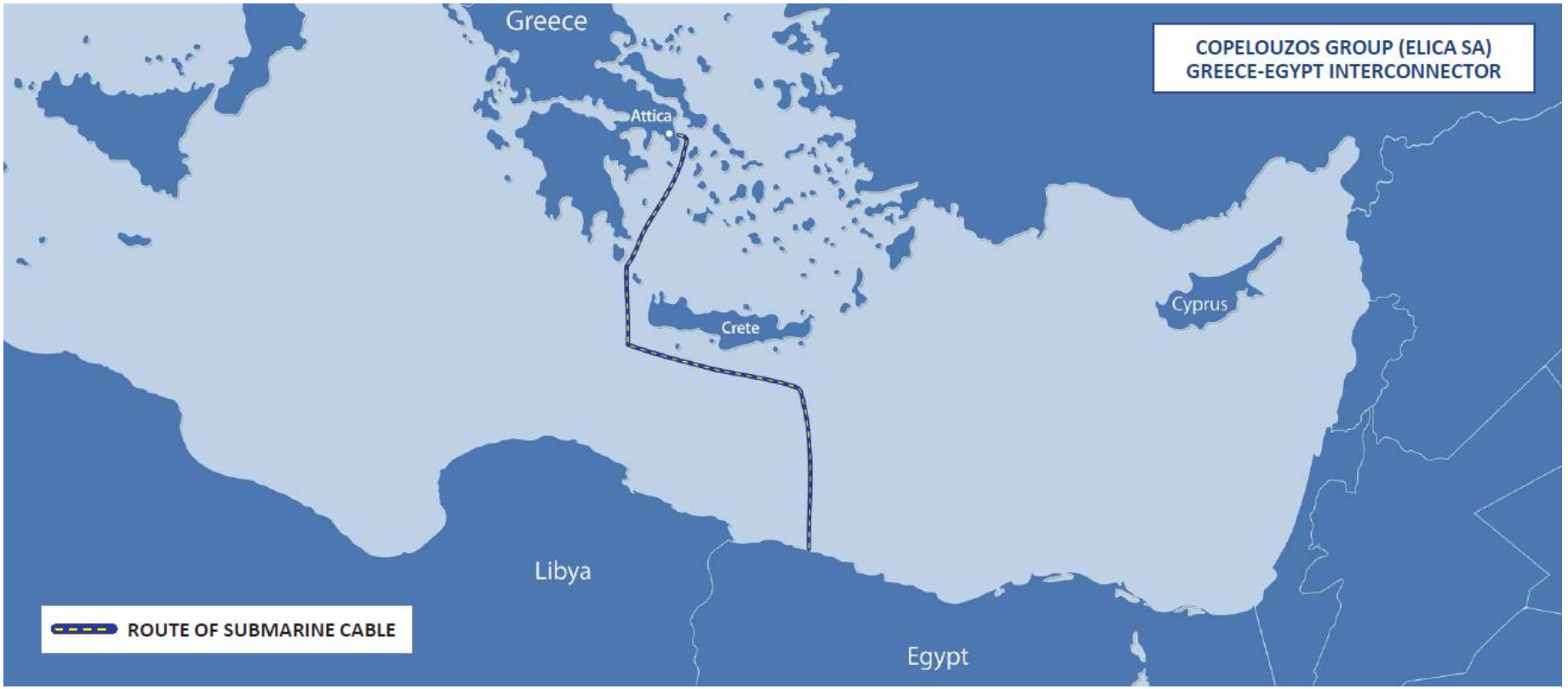
Source: IPTO's Ten Year Network Development Plan 2023-2032

Major Electricity Interconnection Projects in SE Europe - Great Sea Interconnector



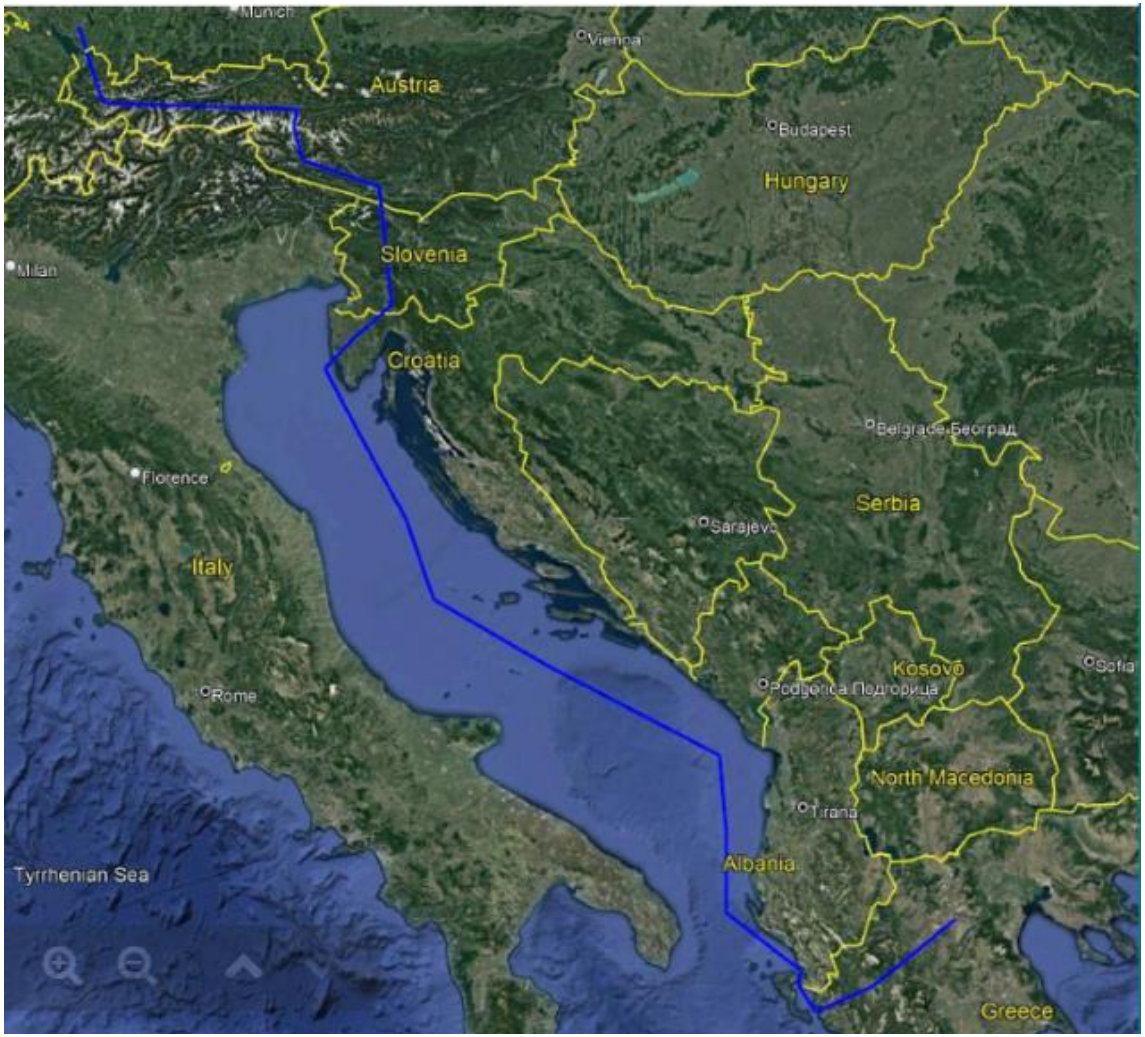
Source: IPTO

Major Electricity Interconnection Projects in SE Europe - Greece-Egypt Electricity Interconnector



Source: ELICA Group

Major Electricity Interconnection Projects in SE Europe - Green Aegean Interconnector



Source: IPTO

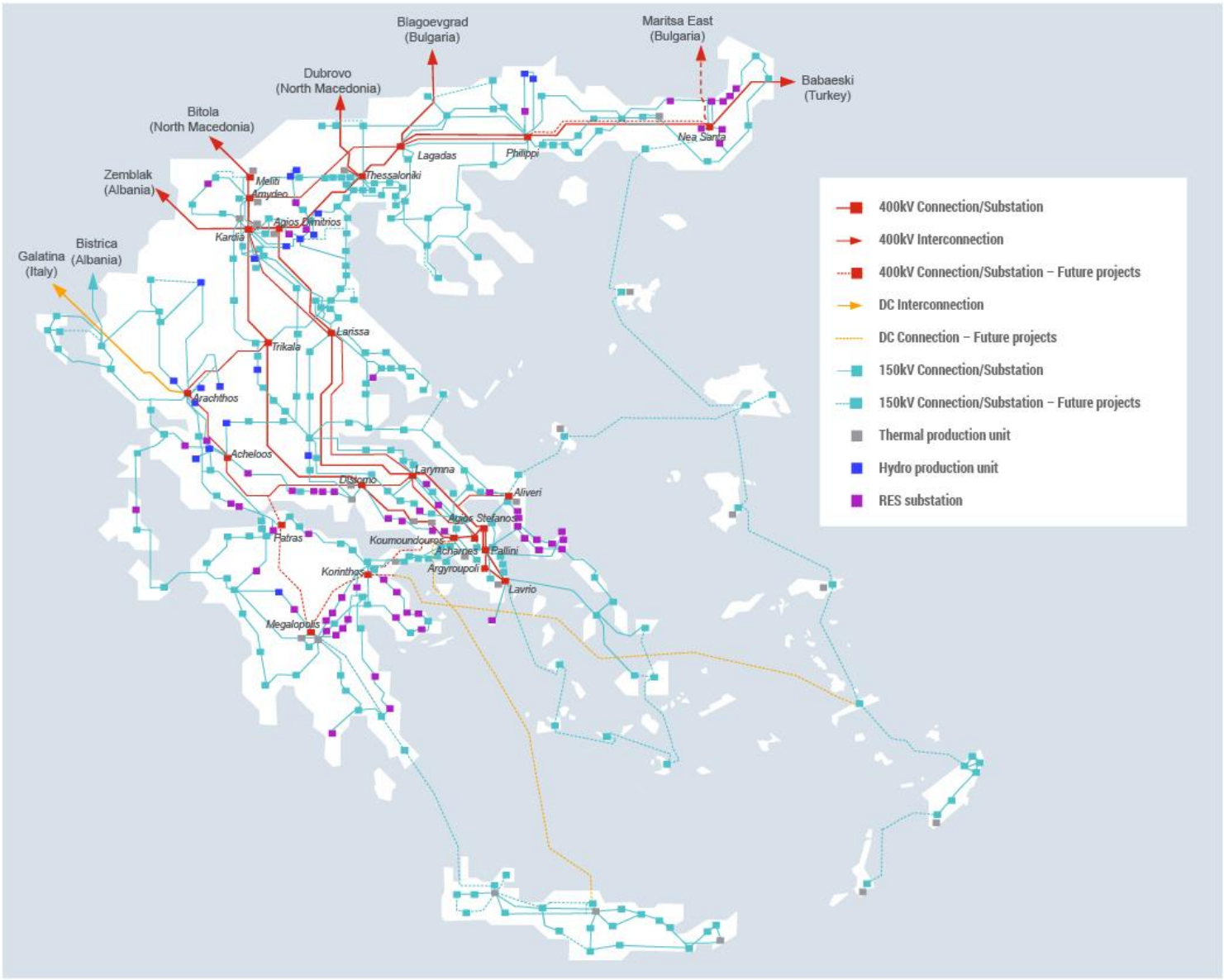
Electricity Interconnections and Energy Storage - The Case of Greece

- As electricity interconnections increase in Greece's mainland and islands, it is estimated that the penetration of renewable energy sources and hence the energy storage needs will rise.

- In Greece, important electricity interconnection projects are progressing, such as in the Cyclades, the NE Aegean and the Dodecanese, while the most important project is the interconnection of the mainland with Crete, which is being carried out in two phases: (a) the small interconnection of Crete-Peloponnese (completed) and (b) the large interconnection of Crete-Attica, which is expected to be completed in the first half of 2023.

- Despite the extensive electricity interconnections in the islands, there will be 40 non-interconnected small islands for many years to come. These are suitable for the installation of integrated clean electricity systems, using batteries and RES, with the possibility of ensuring energy autonomy of 95%.

Domestic and Cross Border Electricity Interconnections in Greece



Source: IPTO

Huge RES Momentum in Greece

70% RES prior to 2030

1.5 GW storage by 2025

2.5 GW Off-shore Wind

Auctions: RES, Storage, Hybrid

Green Pool

Net-metering

Hydrogen Initiation

Doubling XB interconnections

LNG > 20 bcm

Revamping Networks

Green Funding

22 bn € :

RRF / RePowerEU +

ESPA+ Islands Fund+

Modernization Fund

Licensing Simplified

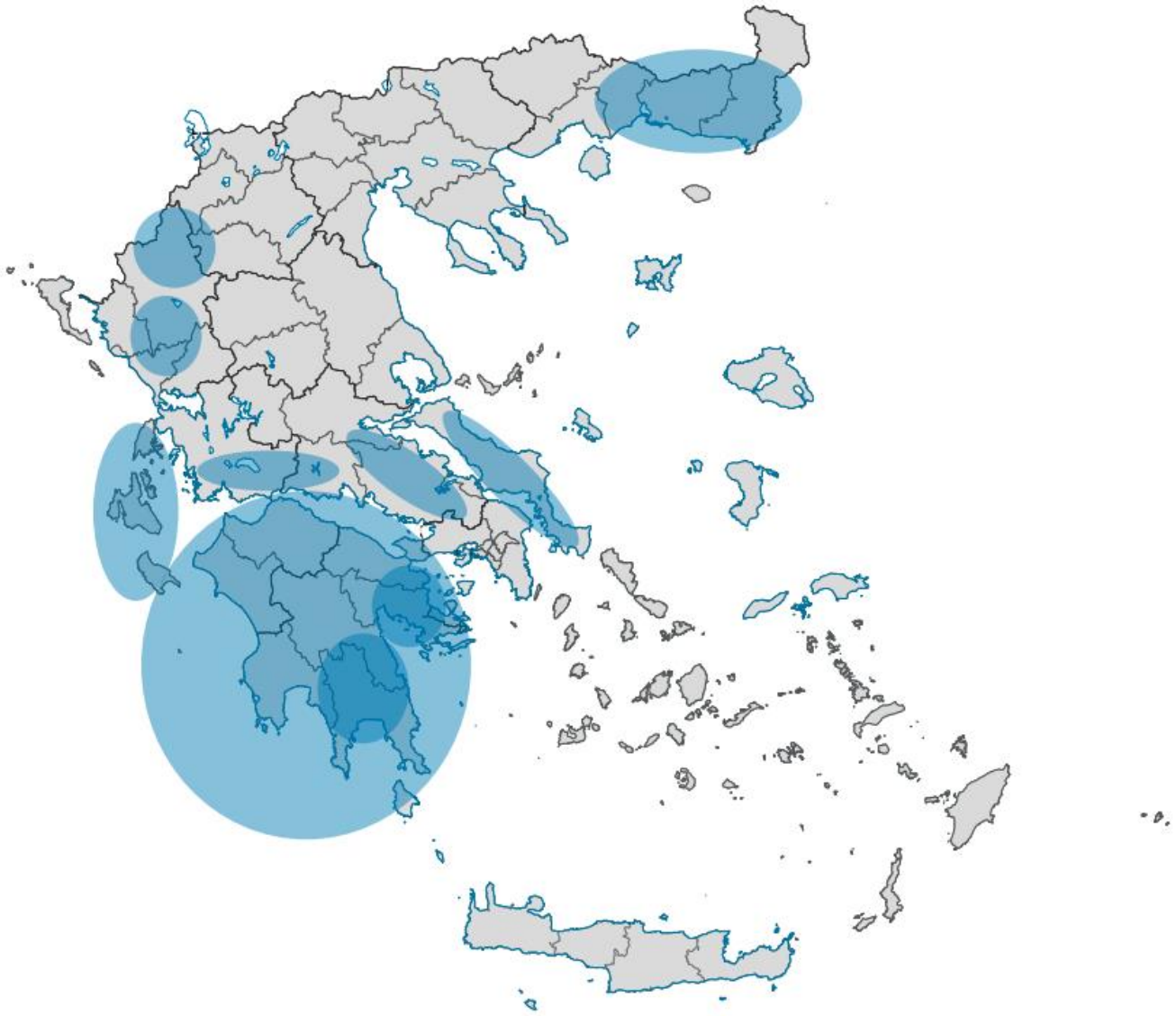
Guarantees

Fair incentives

Energy companies:

Profound and fast green transformation

Areas with High RES Penetration in Greece's Interconnected System

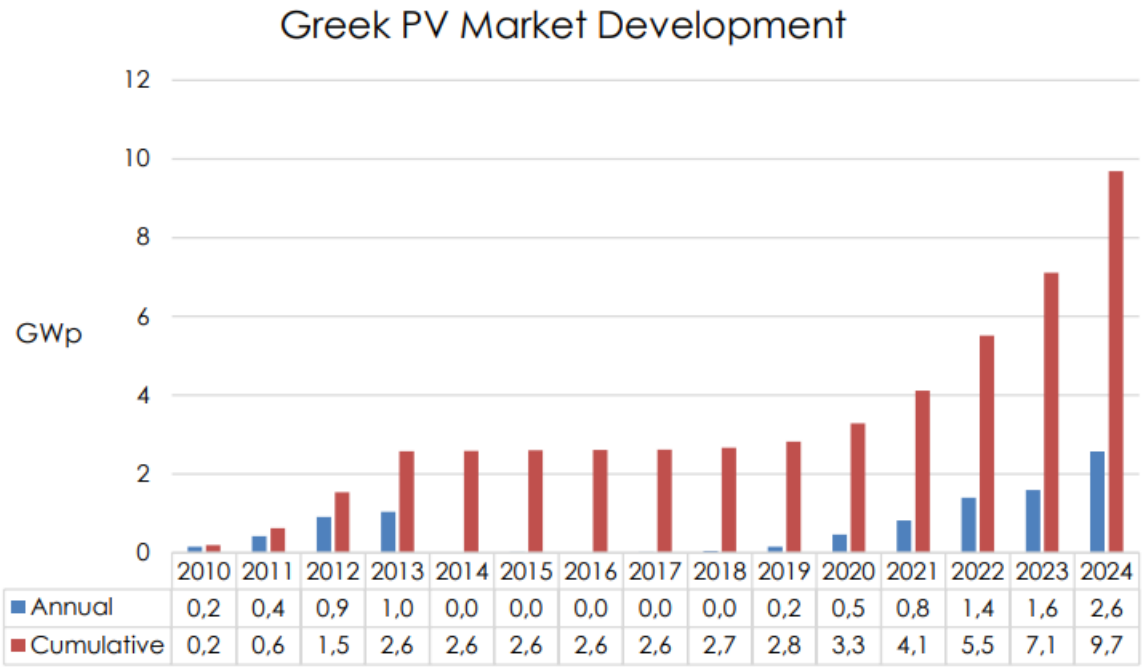


Source: IPTO

Total Installed Wind Capacity (MW) to Greece's Grid, 1999-2024

Source: HWEA

Total Installed Solar PV Capacity (GWp) to Greece's Grid, 2010-2024

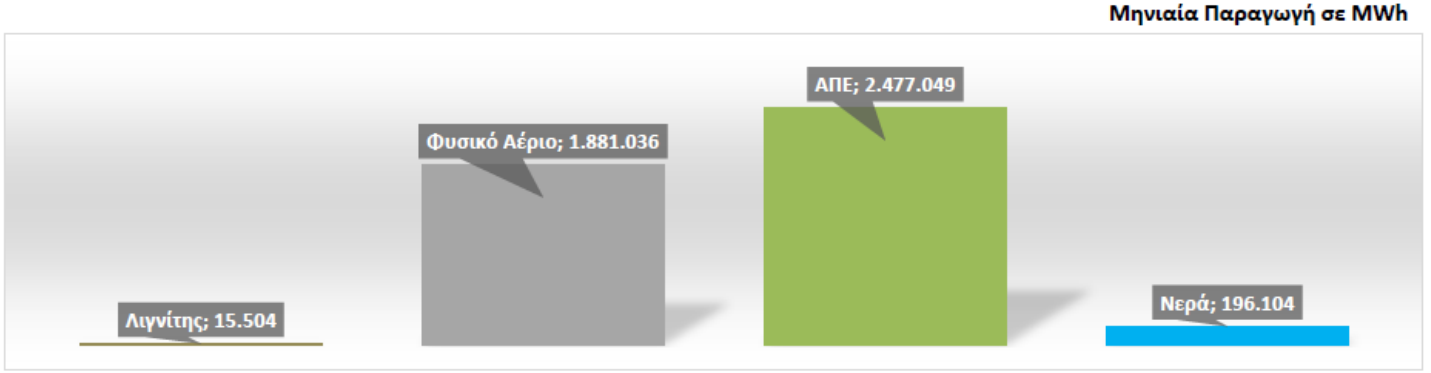


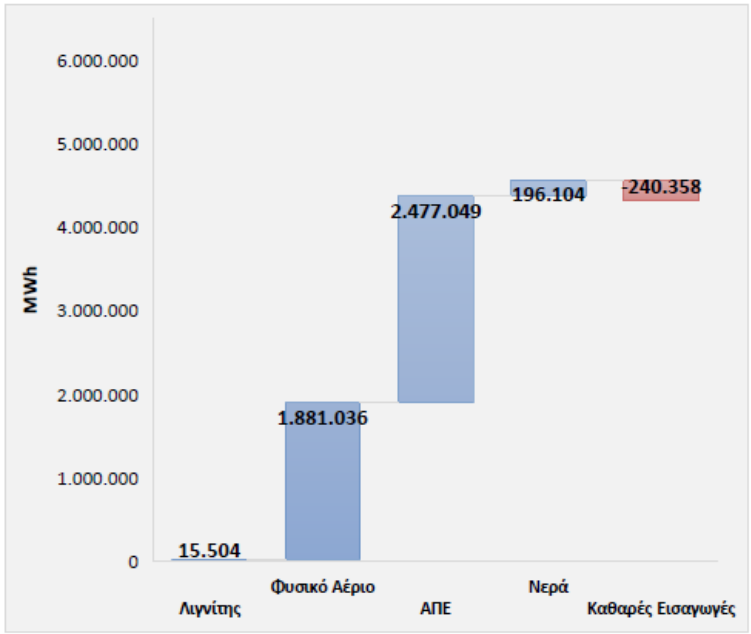
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Annual	0,2	0,4	0,9	1,0	0,0	0,0	0,0	0,0	0,0	0,2	0,5	0,8	1,4	1,6	2,6
Cumulative	0,2	0,6	1,5	2,6	2,6	2,6	2,6	2,6	2,7	2,8	3,3	4,1	5,5	7,1	9,7

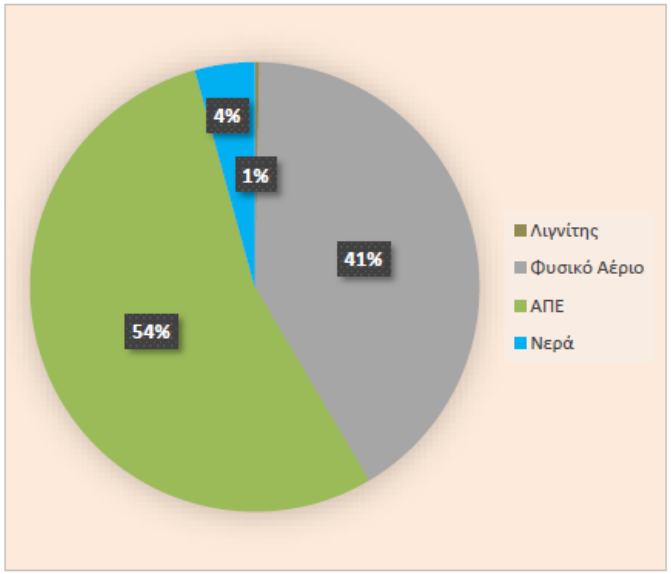
Source: HELAPCO

Greece's Power Generation and Fuel Mix, September 2025

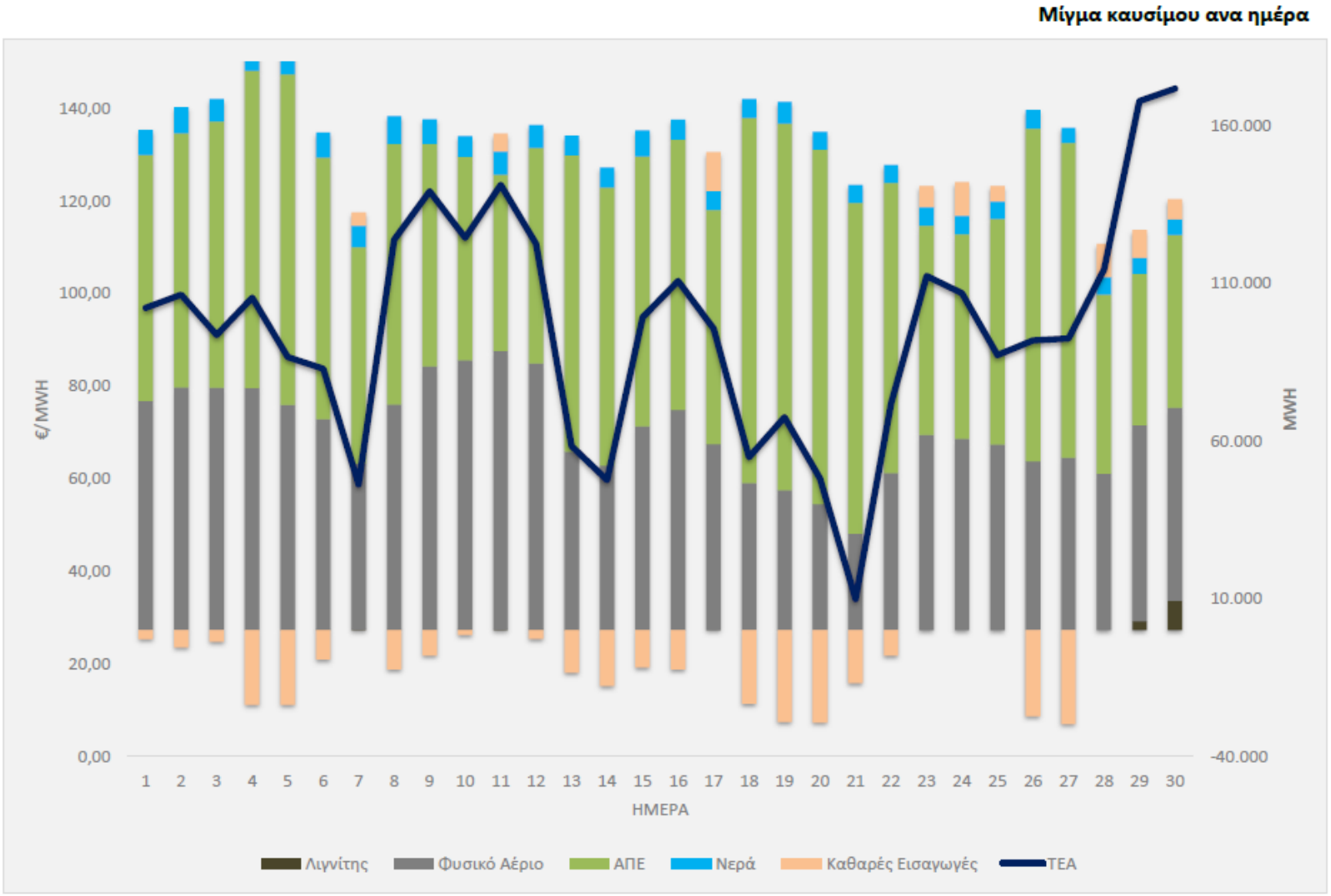
3. Παραγωγή Ενέργειας (MWh) και Μίγμα Καυσίμου



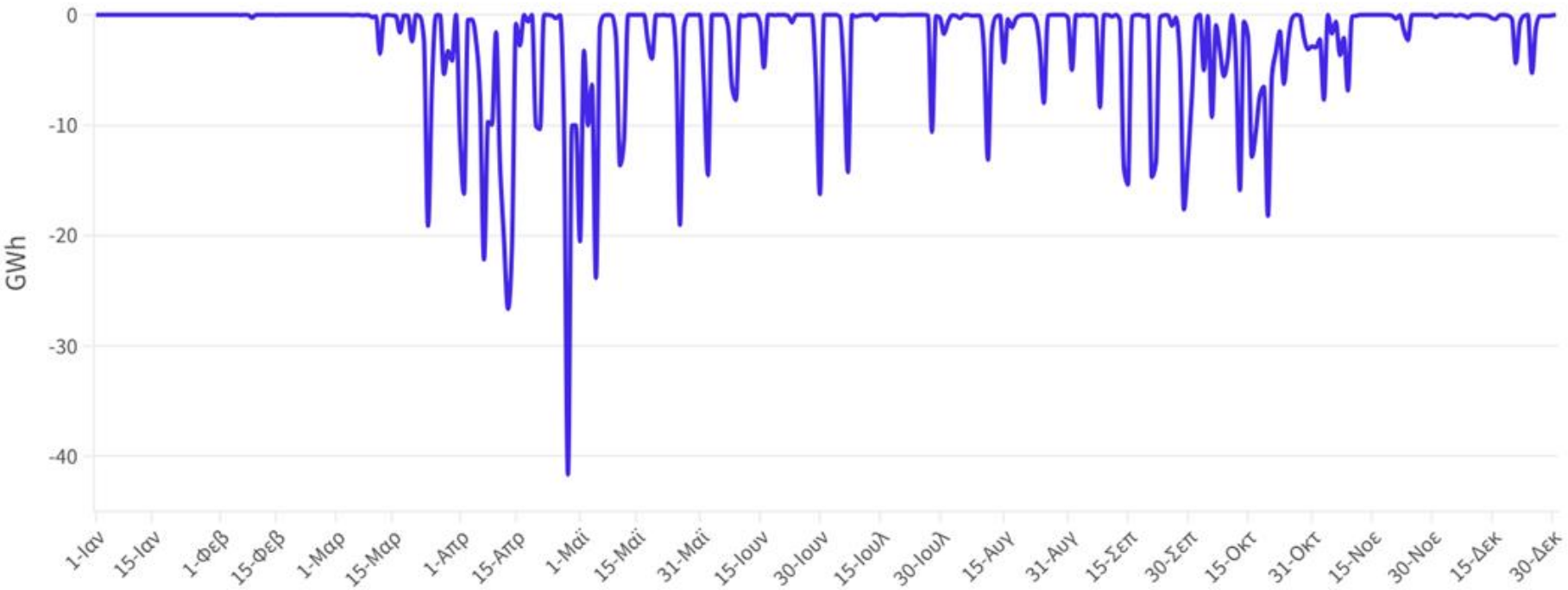




Greece’s Fuel Mix per Day, September 2025

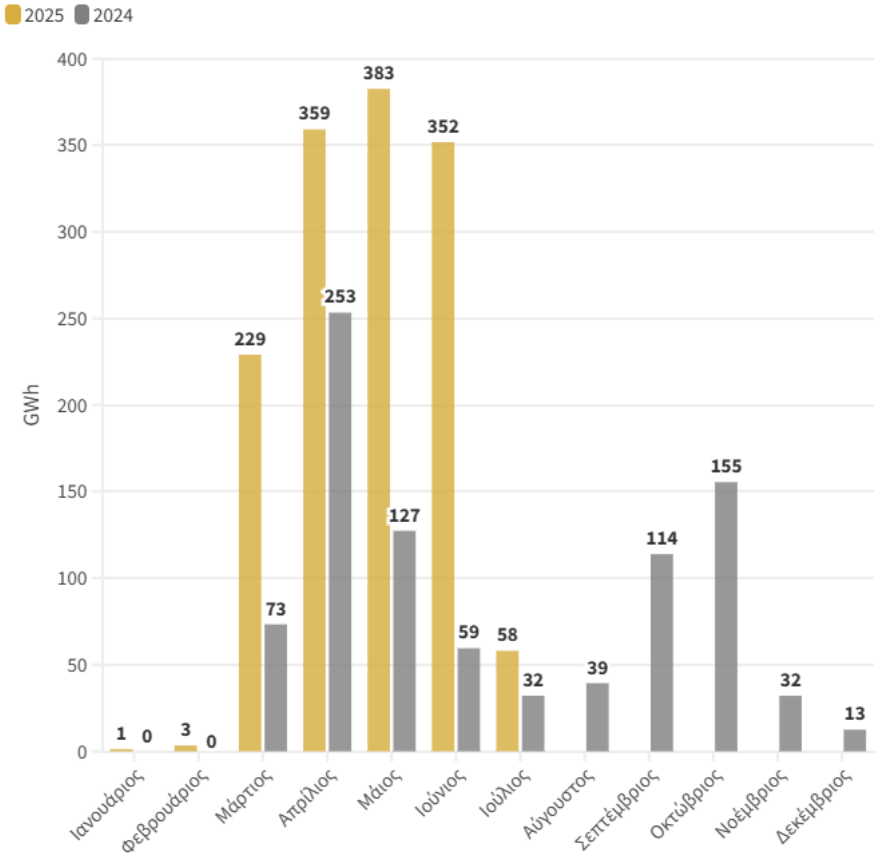


RES Curtailments in Greece, 2024

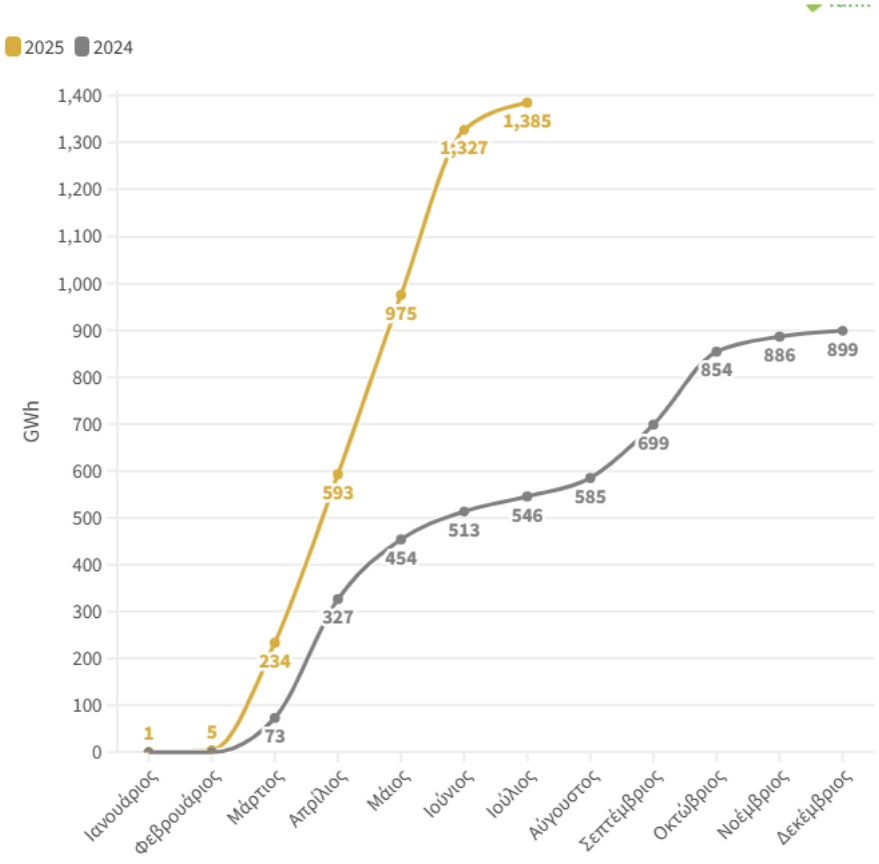


RES Curtailments in Greece, January-July 2025

Cumulatively, in the first seven months of 2025, 1,385 GWh or 8.3% of total RES generation was rejected. This is more than double the RES curtailments of the same period in 2024 (585 GWh).



Πηγή: ΑΔΜΗΕ

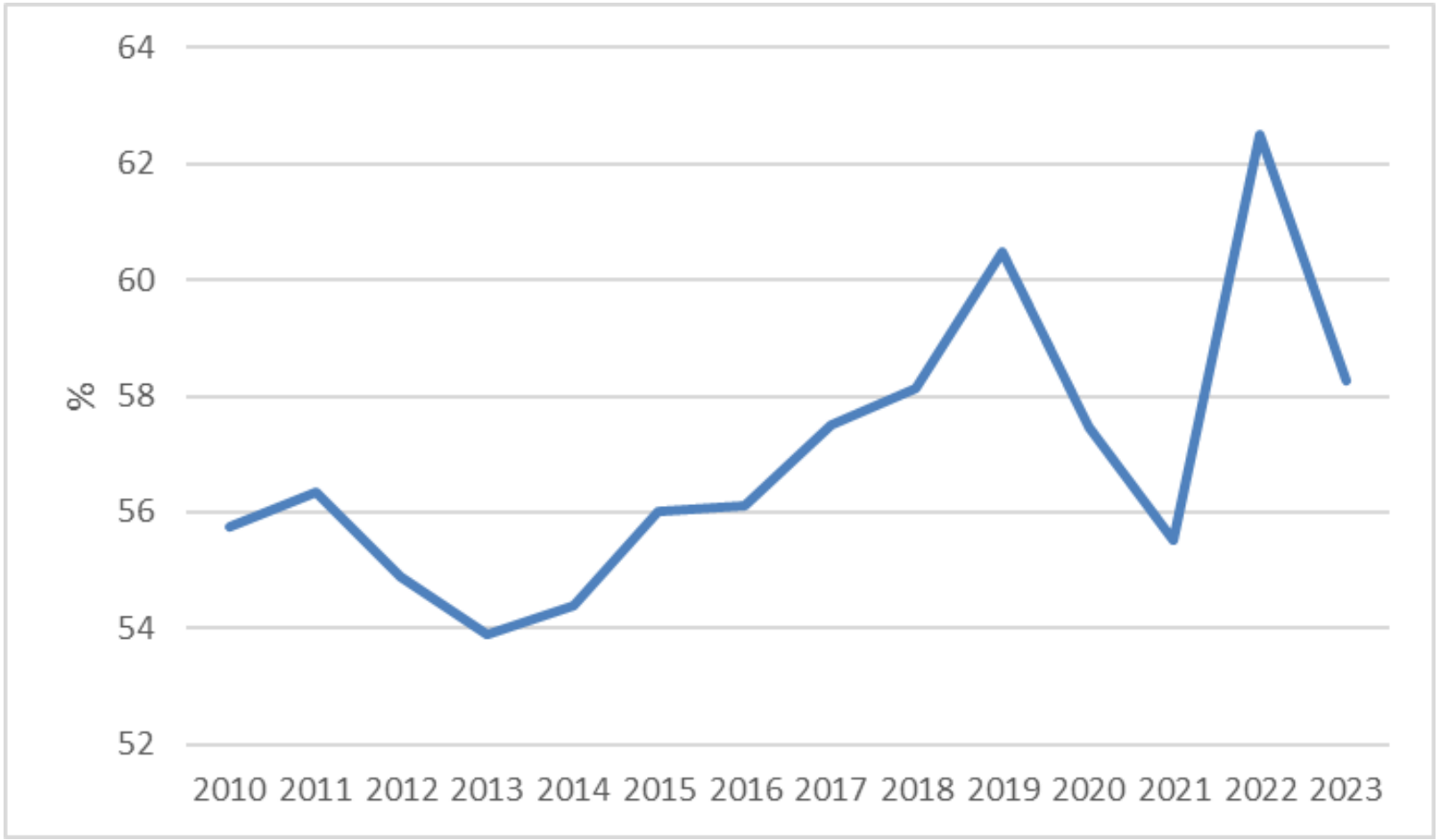


Πηγή: ΑΔΜΗΕ

Energy Security in SE Europe (I)

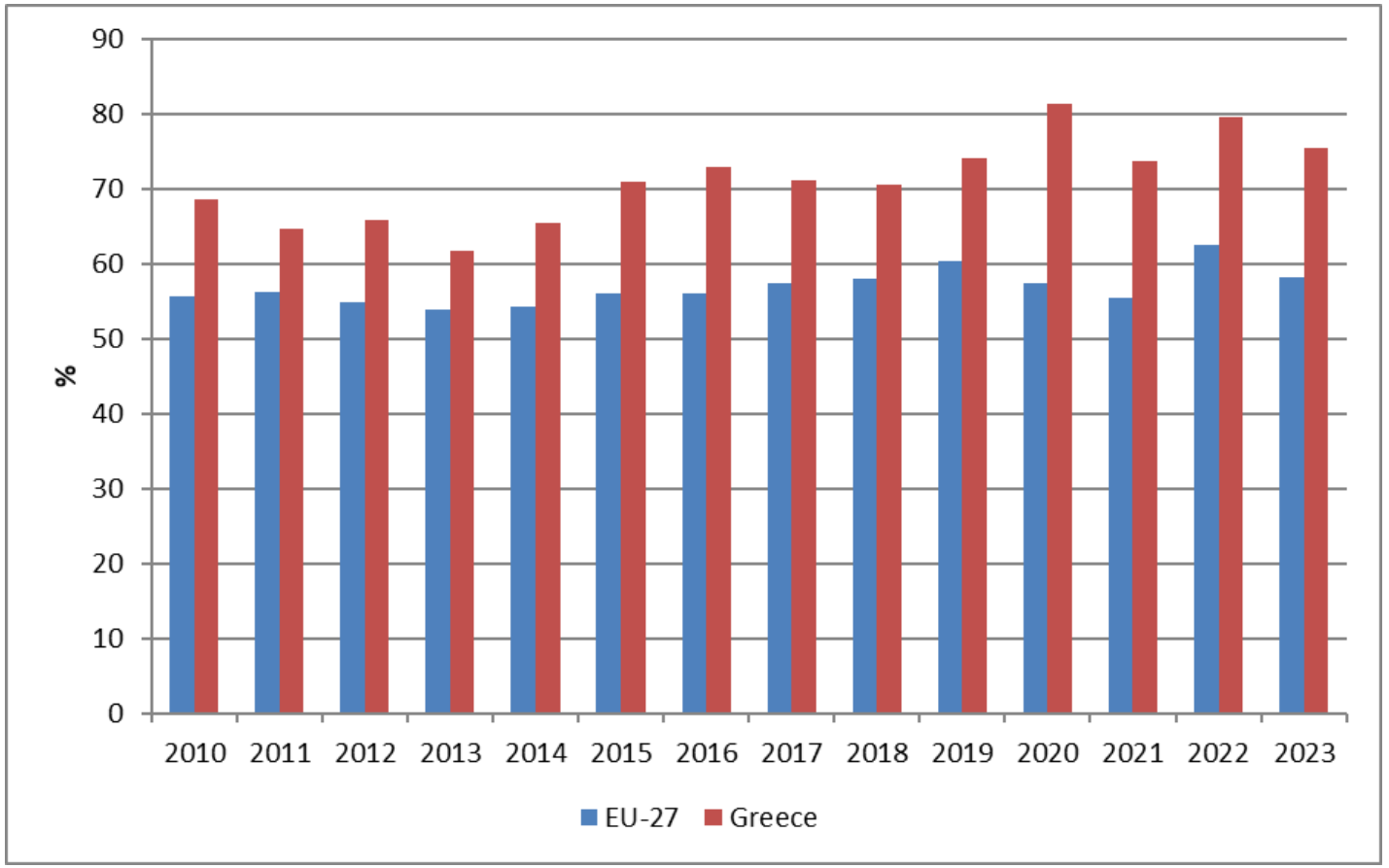
- Energy security is a complex issue and as such cannot be considered in isolation.
  SE Europe, because of its geography, its proximity to high-risk conflict zones (i.e. Syria, Iraq, Ukraine), refugee flow from the Middle East and North Africa and the location of some of its countries (i.e. Turkey, Greece, Romania) at vital energy supply entry points, faces higher energy security threats than the rest of Europe.
- Electricity produced by RES installations, electricity grids and gas supply are closely interlinked as RES cannot operate in vacuum. Hence,decarbonisation policies in the EU and SEE in particular have a clear impact on energy security with most obvious the need to strengthen available mechanisms.
- (a) The strengthening of Emergency and Solidarity Mechanisms and the maintenance of adequate oil, coal and gas stocks, constitute a short- to medium-term relief solution.
  (b) The achievement of a balanced energy mix provides the best long-term option in enhancing energy security both at country and regional level.
- Security of supply/demand and differentiation of supply sources
  In the case of gas, it is becoming more important and pressing compared to other fuel sources, such as electricity, oil, coal and possibly uranium.
  Gas is a primary area of concern largely because of its rather inflexible transmission method, mainly by means of pipelines.

Energy Dependence (%) in Europe, 2010-2023



Sources: Eurostat, IENE

Energy Dependence (%) in EU-27 and Greece, 2010-2023



Sources: Eurostat, IENE

Energy Security in SE Europe (II)

Security of **transportation**, shipment of **oil and gas**

Gas deliveries were twice disrupted (i.e. 2006 and 2009) with the shipment of Russian gas, through Ukraine, to Europe but also from Turkey and Greece (i.e. 2011 and 2016).

Smooth supply of electricity and urgent need to connect various island groups to the mainland grid

Mitigation of possible power supply failures and shortfalls and minimization of environmental impact through the retirement of fuel oil or diesel powered electricity generators on several islands.

Effective protection of energy infrastructure

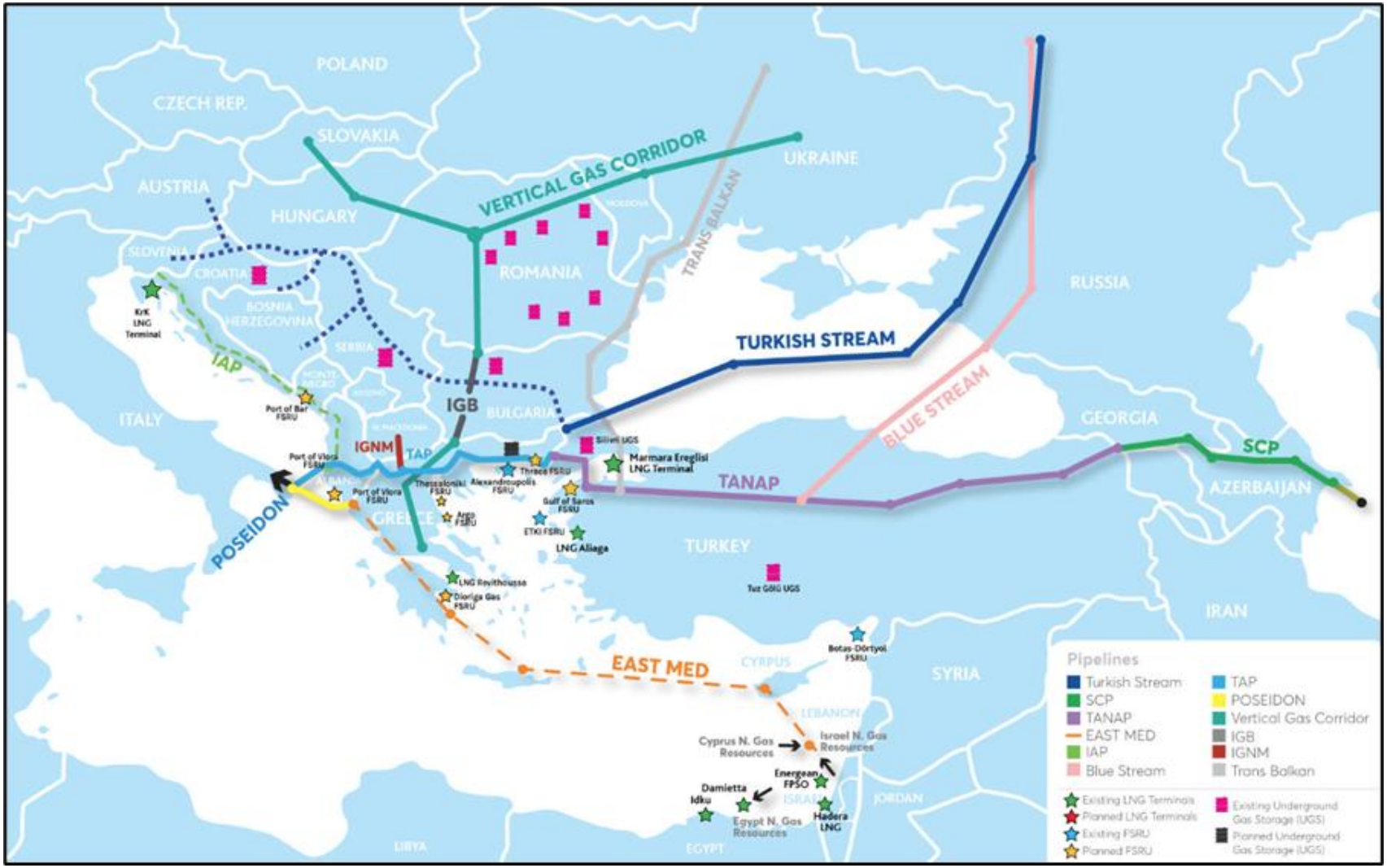
Mitigation of terrorist threats and advanced level of safety against of physical hazards (e.g. hurricanes, floods, earthquakes) and cyber threats (*IENE organised an Ad hoc meeting for energy security on March 15, 2017*).

The various vulnerable key energy infrastructure locations in SE Europe constitute **potential energy security hot spots** and as such should be properly identified, while also crisis management plans must be prepared in order to meet any emergencies (e.g. physical hazards, large-scale industrial accidents or terrorist actions).

Energy Security in SE Europe (III)
- The Key Role of Gas and the Expanded South Corridor

- The South Corridor has key role in enhancing European Energy Security by ensuring the free flow of gas from Azerbaijan, via Türkiye, to SEE and then to Europe proper.
- With gas having emerged as a strategic fuel, the South Corridor has provided the basis for additional gas related infrastructure including cross- border gas interconnectors and LNG plants.
- Meanwhile, several gas exploration projects are in the development stage in the **East Mediterranean** region, with important gas discoveries such as the Leviathan and Tamar fields in Israel, Zohr in Egypt and Aphrodite (which borders with Zohr), Zeus and Cronos in Cyprus's EEZ.
- A number of alternative plans are under discussion for channeling this gas to Greece and Turkey, for local consumption, but also to Europe proper for transit to the continent's main gas markets. These plans include gas pipelines, liquefaction plants for LNG export and FSRU terminals to be tied up into the TANAP-TAP system.
- Another option apart of TAP – TANAP system is the **East Med Pipeline** which again, due to the significant technical challenges, could also accommodate limited quantities of gas in the regions of 8.0 to 12.0 BCM's per year. Meanwhile, EC is actively exploring the possibility of massively increasing the member countries' LNG capabilities as part of Energy Union priorities, despite the recent negative stance from the US.

An Expanded South Gas Corridor



Source: IENE

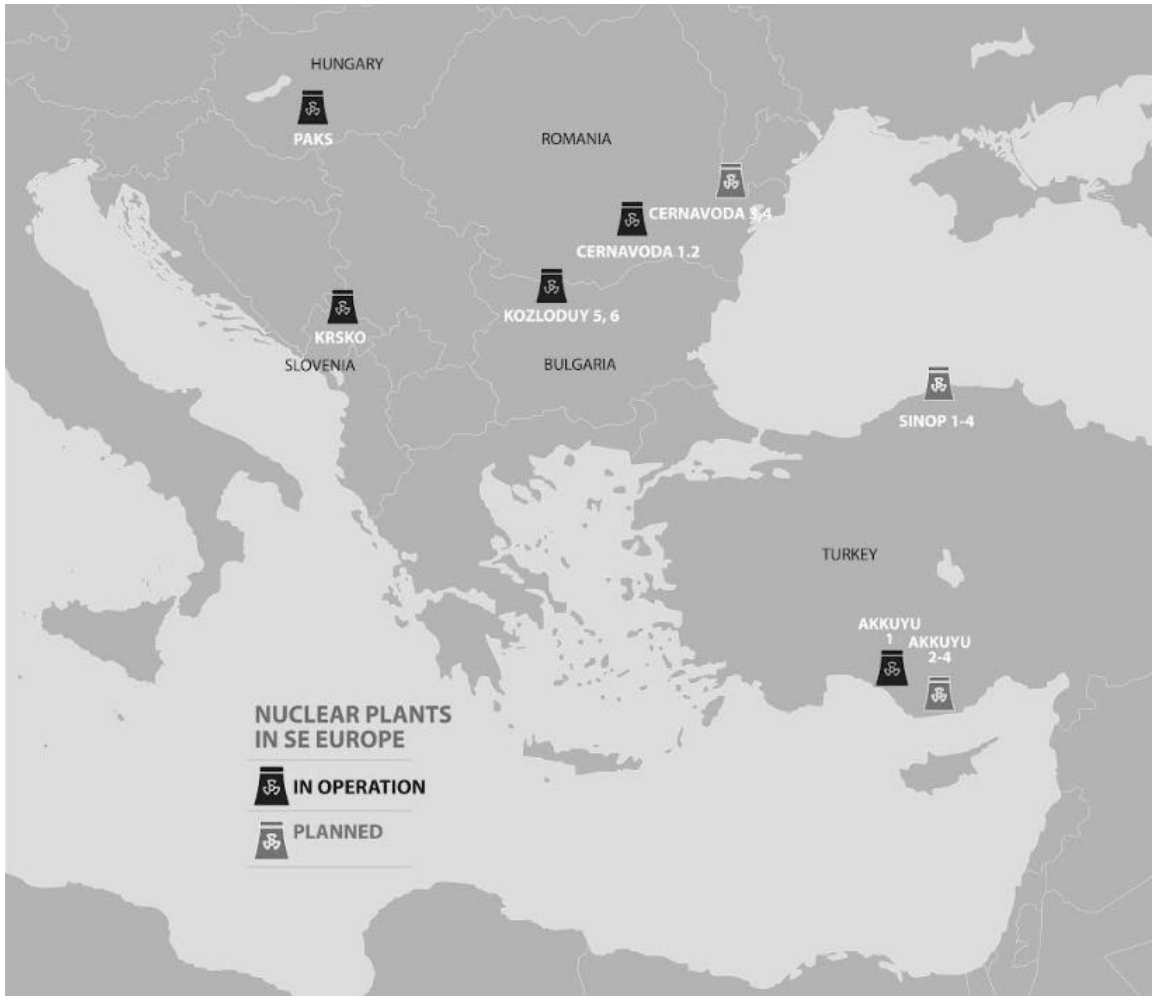
The Vertical Corridor

Source: DESFA

A Holistic Approach to Energy Security

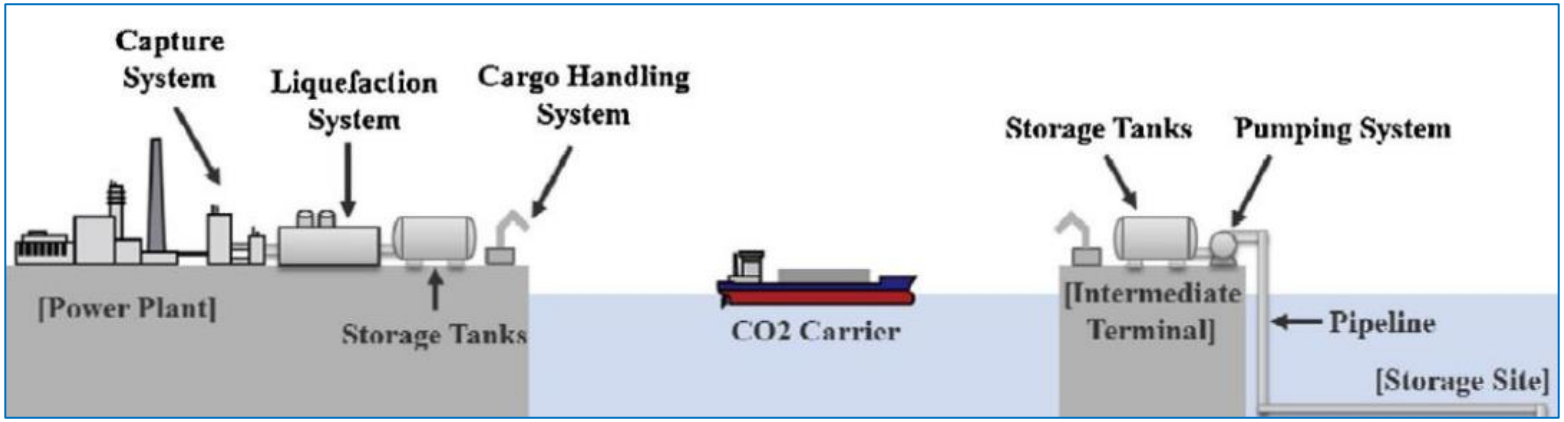
- For Renewables to be able to provide an alternative solution in enhancing energy security, we need reliable base load electricity. This can be provided only through natural gas operated CCP and nuclear plants. To that we should add pumped hydro schemes and electric batteries.
- Demand side management of the energy system through nation wide programmes to improve energy efficiency (primarily in buildings) must also accompany our efforts to enhance energy security. By using smart electricity and gas meters we can predict more accurately the demand curve and hence plan accordingly the operation of the electricity plants on an hourly basis.
- A basic network of nuclear facilities, already exists and is spread in 5 countries in the region with good prospects for further expansion, especially through the introduction of SMRs. Nuclear power is comparable with increased RES use since it provides much needed base load and ensures steady prices in the long term.
- Also, CCUS is becoming relevant in the region, with Greece at the forefront through the development of CCUS industry-oriented hubs.
- In the area of Energy Efficiency, there are several large-scale programmes running in most countries, with EU and state help which are helping transform the energy environment by cultivating new consumer attitudes and approaches to everyday life. These programmes normally have a multiplying effect and it is no exaggeration to state that they help improve overall efficiency in a country's energy system. This is already reflected to a certain degree in the decelerating energy demand growth.
- In this context, an understanding of the energy demand in the region is necessary. We would like to know how demand is going to shape over the next 25 years or so and how is this going to affect the needs for new energy infrastructure.

Nuclear Power Plants in SE Europe



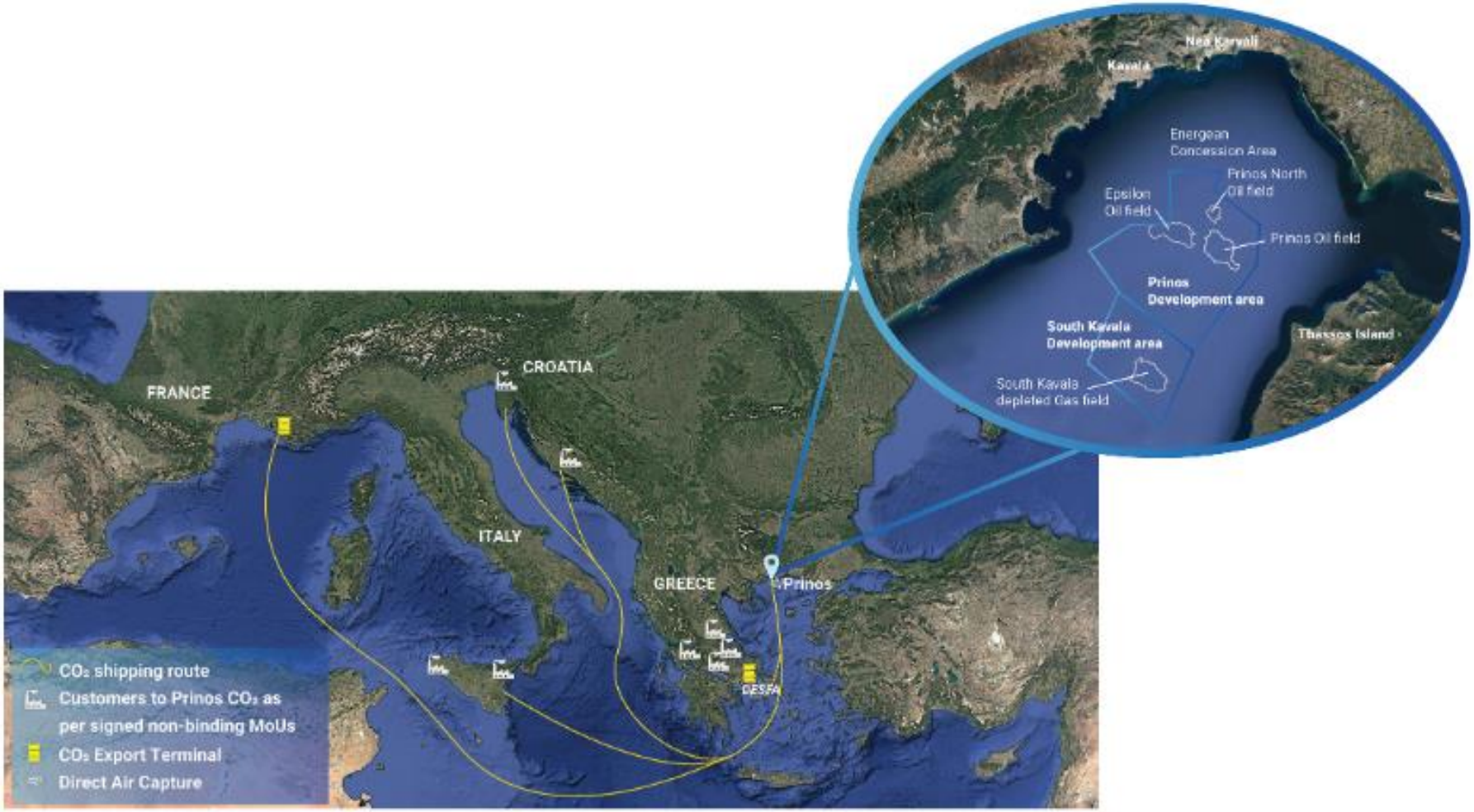
Source: IENE

Concept of Ship-based CCUS Hub



Source: IENE

Prinos CO2



Source: Energean

Energy Demand in SE Europe: A Scenario Approach

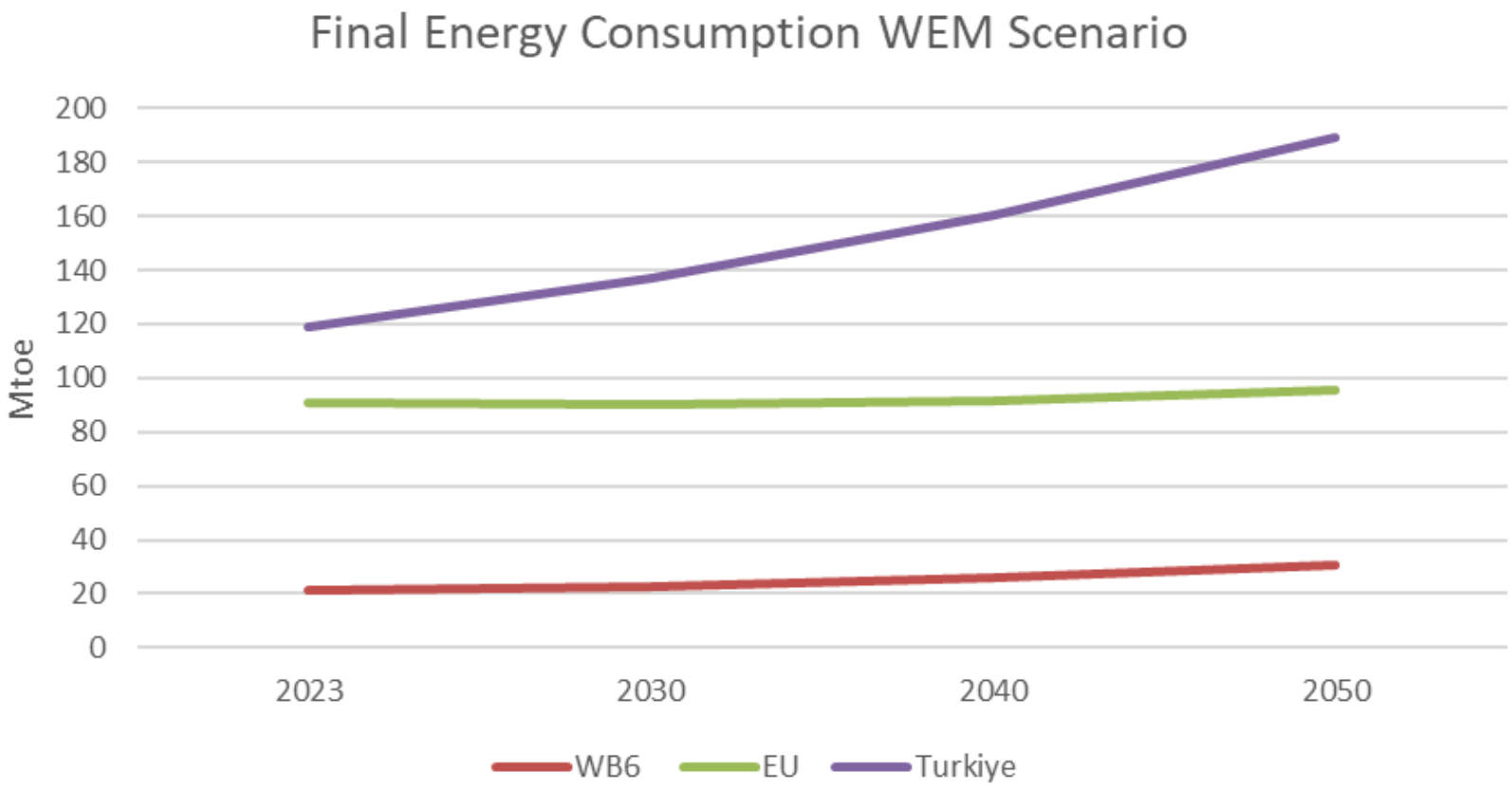
Three scenarios are analysed in the latest “SEE Energy Outlook 2025” study:

1. The **WEM scenario (With Existing Measures)** represents a continuation of current efforts and policies, capturing a CO2 trajectory at the sectoral level derived from the national strategies, National Energy and Climate Plans and UNFCCC submissions of the countries, without additional mitigation ambition.

2. The **WAM scenario (With Additional Measures)** reflects enhanced efforts still within a non-net-zero framework; it applies more ambitious but still realistic sectoral CO2 reductions, based on the same national sources as WEM.

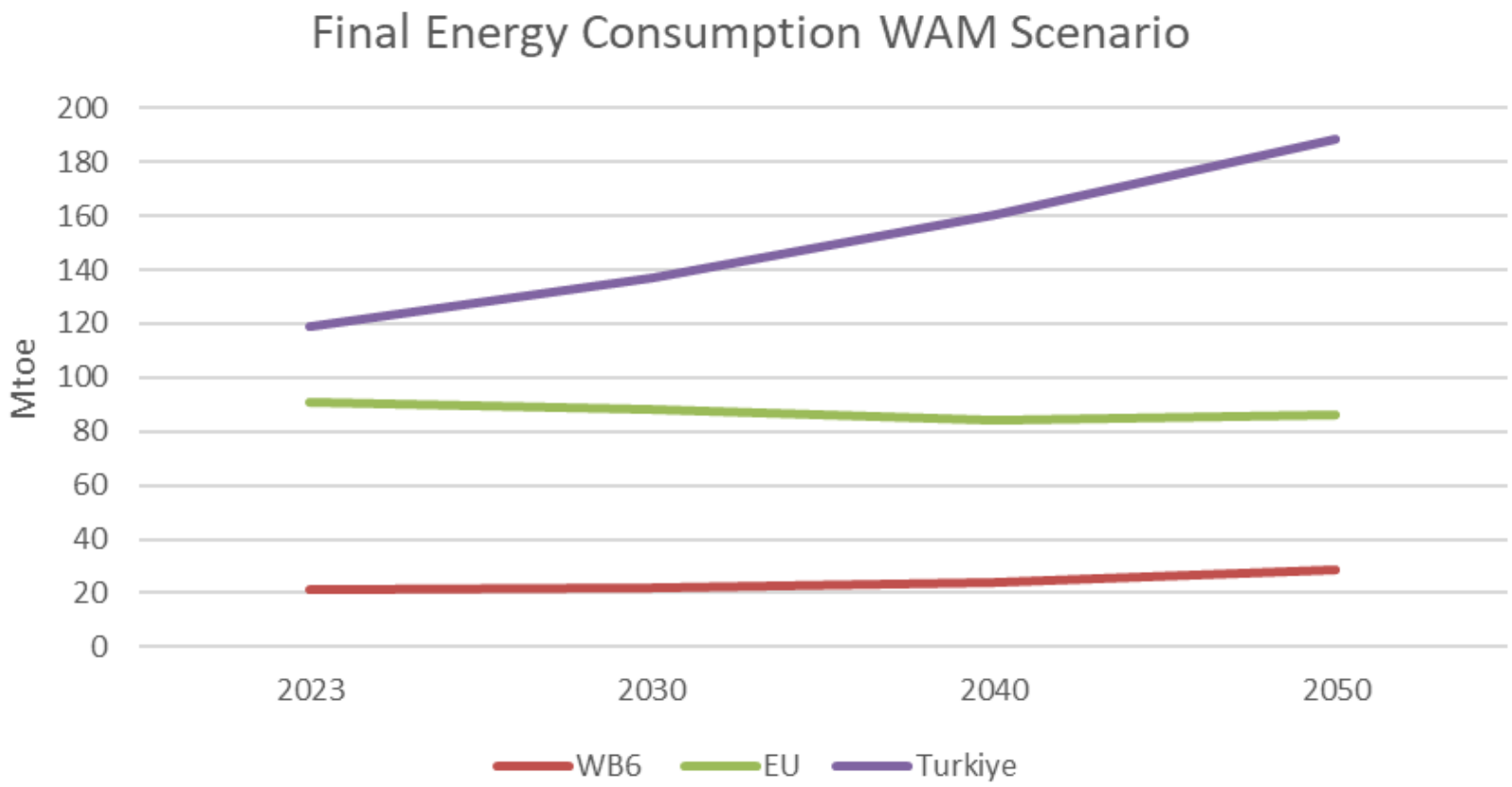
3. Finally, the **NZ (Net Zero)** scenario builds upon the sectoral goals of the WAM scenario and applies an overarching constraint of achieving net zero greenhouse gas emissions at the national level for each of the targeted countries, thereby forcing a system-wide transformation in line with long-term climate neutrality targets.

Final Energy Consumption in SE Europe per Group of Countries, 2023-2050 (WEM Scenario)



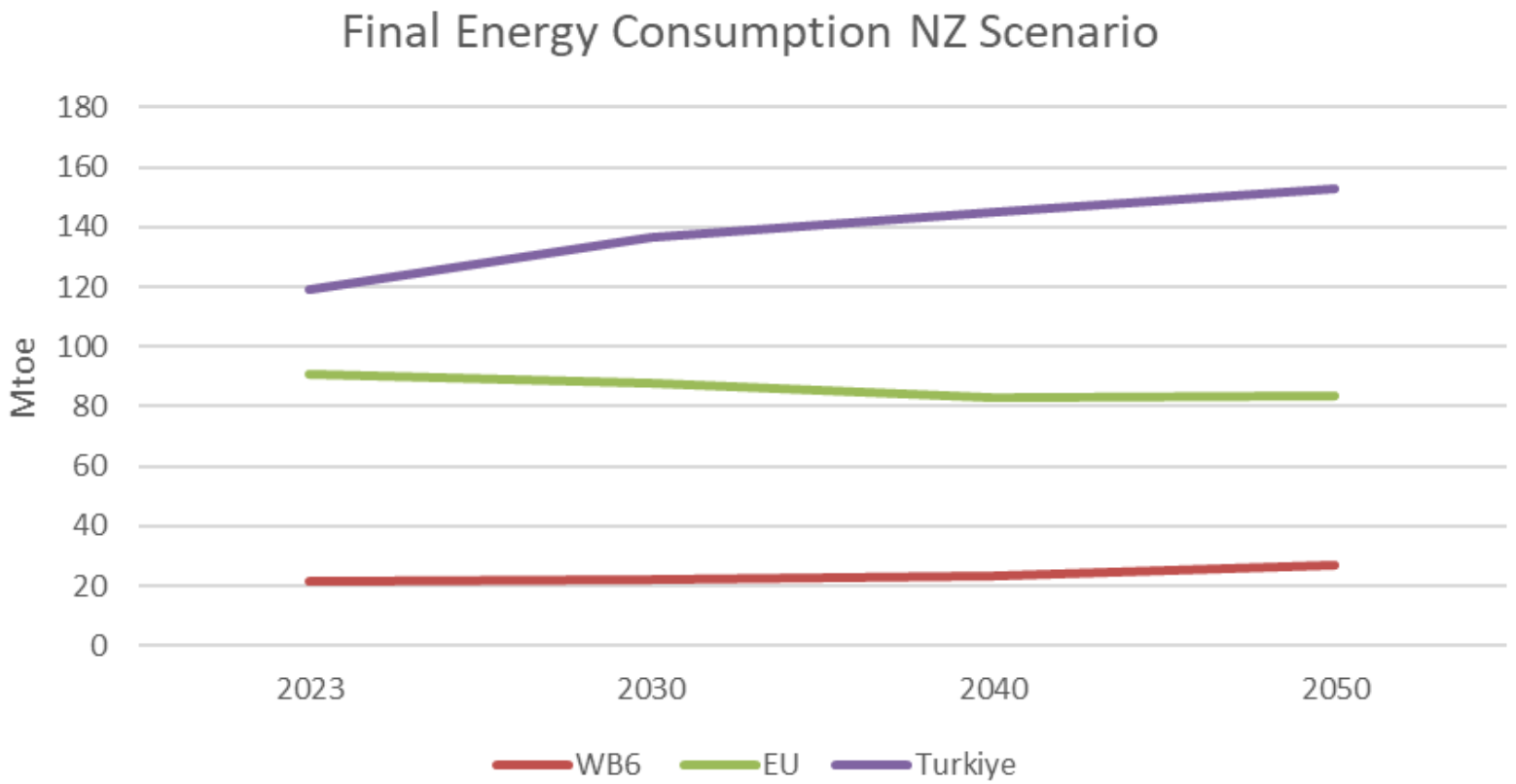
Source: IENE

Final Energy Consumption in SE Europe per Group of Countries, 2023-2050 (WAM Scenario)



Source: IENE

Final Energy Consumption in SE Europe per Group of Countries, 2023-2050 (NZ Scenario)



Source: IENE

Concluding Remarks

- Energy policy at EU level but also at government level in SE Europe needs to be urgently revised in view of rising energy security concerns
- At a time when the adequate and continuous energy flows cannot be guaranteed, the EU and national governments must realign energy policies in order to strengthen energy security with decarbonisation taking second place
- Decarbonisation policies should also be revised to consider greater use of natural gas, non-intermittent RES, nuclear power and advanced technologies aiming towards cleaner fuels
- In view of the large-scale penetration of intermittent renewables in the electricity mix of various countries, and the problems encountered with curtailments and fragile system management, it is necessary to channel a lot more investment in strengthening and upgrading electricity grids
- In view of persistently high electricity prices in most SEE countries (higher than the rest of Europe), there is an urgent need to harmonise electricity market operation across the region and at the same time facilitate cross border energy flows
- In this context, the real cost of installing and maintaining an ever-expanding RES capacity and the necessary storage back-up, needs to be fully analysed and factored in when charting ambitious decarbonization policies which tend to ignore the rising cost to consumers
- Ultimately RES operation needs to be rationalised if governments and utilities are to reign on unjustifiable high electricity prices in the SEE region
- As energy security priorities take hold, governments would be well advised to aim towards a balanced energy mix as the best insurance policy against supply disruptions and energy poverty

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