KPMG

# The Future of the Energy Sector

Focus on the Greek Electricity Market

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# Introduction

Electricity plays a pivotal role in numerous aspects of contemporary life within modern societies, and its significance is expected to grow further as it assumes a more substantial role in transportation and heating, thanks to technologies like electric vehicles and heat pumps. Simultaneously, the ongoing global energy crisis has elevated concerns about electricity security and affordability to prominent positions on the political agendas of many nations.

Power generation stands as the primary contributor to global carbon dioxide (CO2) emissions. However, it is also at the forefront of the shift toward achieving net-zero emissions by rapidly increasing the adoption of renewable sources like solar and wind power.

## Demand Side

In 2022, electricity consumption in the **European Union** saw **a notable drop of 3,5%** compared to the previous year. **Greece** followed the same trend with a year-over-year **decrease of 3,3%.**

This decline was mainly attributed to the region's grappling with soaring energy costs, which resulted in substantial reduction in demand, especially among industrial users. Additionally, an unusually mild winter exerted further downward pressure on electricity consumption.

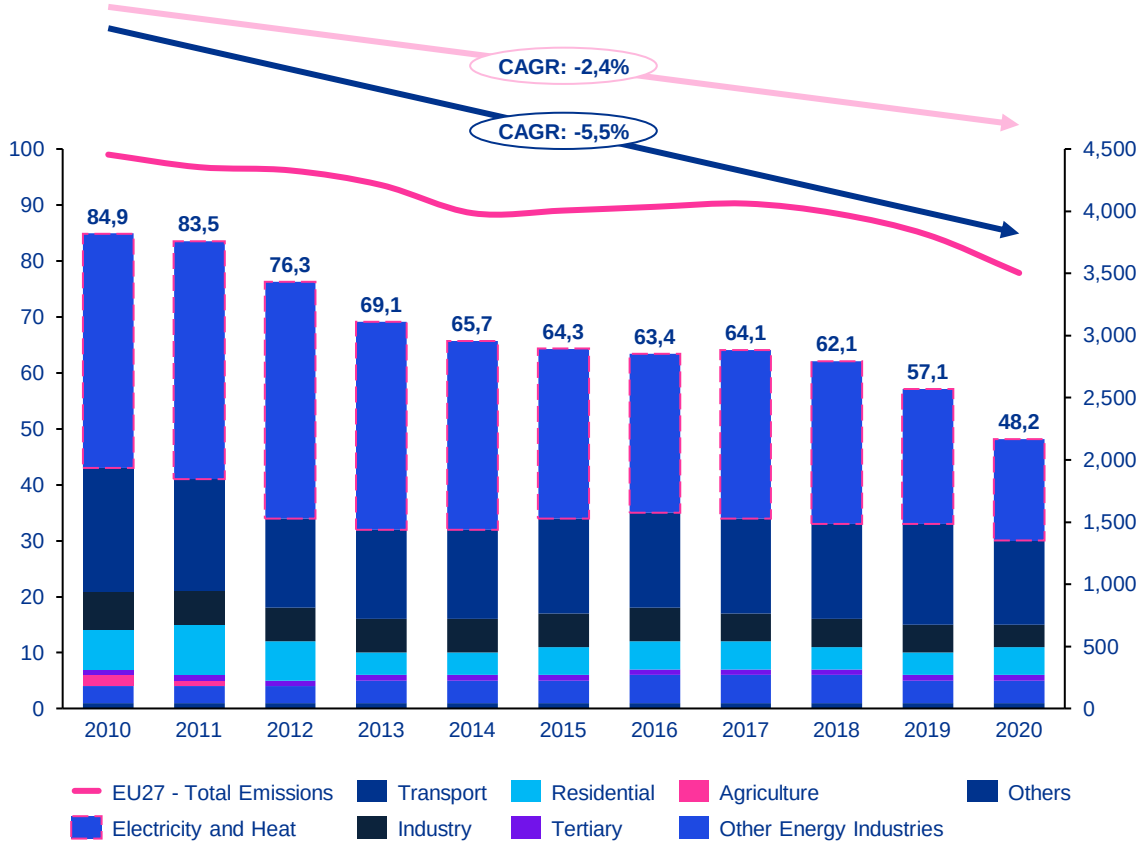
## Supply Side

Power generation in the **European Union and Greece decreased by 3% and 4%** respectively compared to 2021 in terms of produced volumes. However, an **increase in electricity from RES** was noticed both in the **EU (+0,8%)** as well as in **Greece (+2,7%)**.

In terms of capacity, Greece increased its renewable energy capacity by **1,5 GW (+12,2% vs 2021)** mainly thanks to the high penetration of solar technology, outperforming the EU average of +10%.

# Electricity and heat production is currently the largest source of CO2 emissions, in an environment of rapidly increasing CO2 prices…

## CO2 emissions by sector in Greece (in MtCO2)




**Sources:** Eurostat, IEA, KPMG analysis

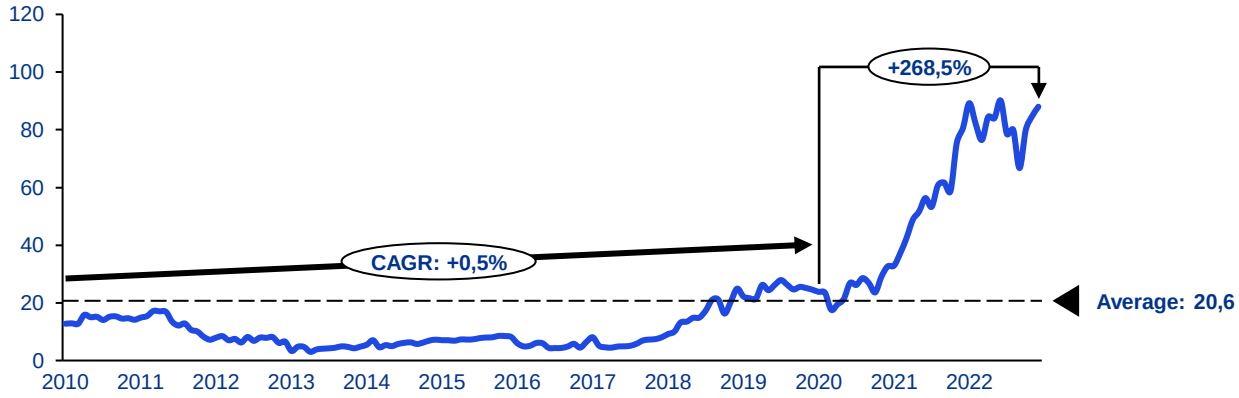
Addressing CO2 emissions is crucial to mitigating climate change, biodiversity loss, rising sea levels and other challenges and ensuring a sustainable and habitable planet for future generations.

Greece decarbonization efforts are taking place at a higher pace compared to the average EU27 having **reduced the total CO2 emissions by 44%** in 2020 compared to 2010 vs 21% of the EU average.

GHG emissions originating from Greece's **electricity generation plants are subject to regulation through the Emissions Trading System (ETS).** The ETS is the sole carbon-pricing mechanism employed within Greece.

During the examined period, EU permits are rather stable from 2010 up to late 2020, while post this period the ETS prices skyrocket, surpassing 90€/tnCO2.

## EU Carbon Permits (in €/tCO2)



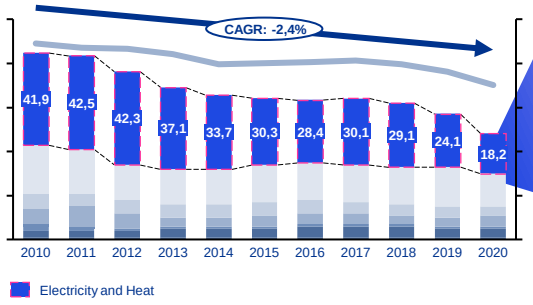
# ...but it is also the sector that is leading the transition to net zero

Greece is enacting extensive reforms within its energy sector to promote decarbonization and encourage the development of competitive markets.

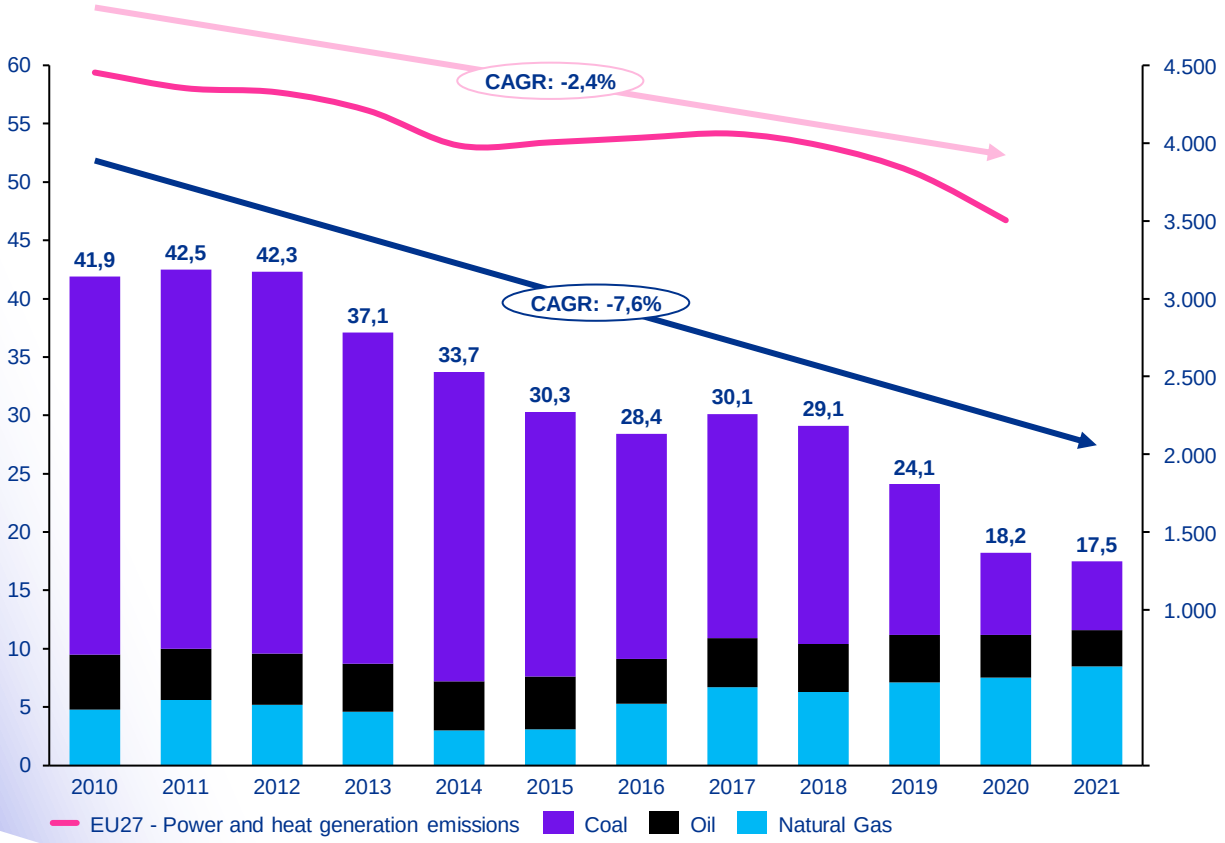
In absolute terms, the power generation sector in Greece has **decreased its CO2 emissions be more than 58%** compared to 2010 levels. This is mainly attributed to the large decrease of lignite generation and the uptake of renewable energy.

Additionally it can be noted that Greece's prementioned reduction of -58% is significantly higher vs the -21% of the EU27 average.

## CO2 emissions by sector in Greece (in MtCO2)




## CO2 emissions in power and heat generation in Greece (in MtCO2)




**Sources:** Eurostat, IEA, KPMG analysis

# Greece has made notable progress towards meeting its National Targets for 2030 however significant challenges remain

Being a member of the European Union, Greece has set ambitious environmental goals, targeting a 55% reduction in overall greenhouse gas emissions by 2030, with the ultimate aim of achieving net-zero emissions by 2050. Substantial strides have already been taken towards these objectives. The National Climate Law, which has been adopted since May 2022, targets the aforementioned reductions, however the main document to set energy and climate policy to 2030 is the highly anticipated revised Greek National Energy and Climate Plan (NECP) which is expected to be submitted to the EU Commission in late 2023.

01 **Deployment of RES**

The expansion of solar and wind energy projects, including the rapid growth of offshore wind initiatives, is set to increase capacity by over 12GW by 2030. Additionally, efforts are underway to fully harness the remaining hydroelectric potential within the country. A dedicated program has been introduced to bolster the adoption of rooftop photovoltaic systems, promote the growth of energy communities, and prioritize photovoltaic installations on industrial and commercial rooftops. There is a recognized strategic significance in advancing offshore wind farms and ensuring the establishment of suitable locations and network infrastructure.

02 **Energy Storage**

As we increase the integration of Renewable Energy Sources (RES), it's imperative to concurrently develop the necessary storage solutions to ensure the system's equilibrium and stability. This includes the implementation of technologies like batteries and pumped-storage systems. A capacity availability remuneration mechanism for the provision of flexibility and reserve services

03 **Energy Efficiency**

Enhancing the energy efficiency of buildings, which entails expediting and substantially expanding renovation efforts while also streamlining financing options, is a critical endeavor. Likewise, the implementation of intelligent energy consumption management systems and encouraging behavioral changes can reduce energy demand or reshape the load curve. There are also plans for the industrial sector, wherein they commit to enhancing energy efficiency and mitigating their carbon footprint as well as a dedicated program focusing on heat pumps, appliance upgrades, lighting improvements and public sector building renovations.

04 **Carbon Neutral Fuels**

Promote the growth of a domestic sector dedicated to manufacturing climate-neutral alternative fuels tailored for transportation sectors that either cannot or prefer not to transition to electrification. The country's refineries should prioritize the production of environmentally friendly alternative fuels and green hydrogen, preserving their export-oriented role for this specific purpose.

05 **Carbon Capture and Storage**

Advancement of investments aimed at capturing carbon dioxide (CO2) from industrial processes, mainly cement industries, refineries and chemicals along with its utilization in the production of synthetic fuels. Simultaneously, efforts are being directed towards the establishment of infrastructure for the geological storage of CO2.

06 **Transport Electrification**

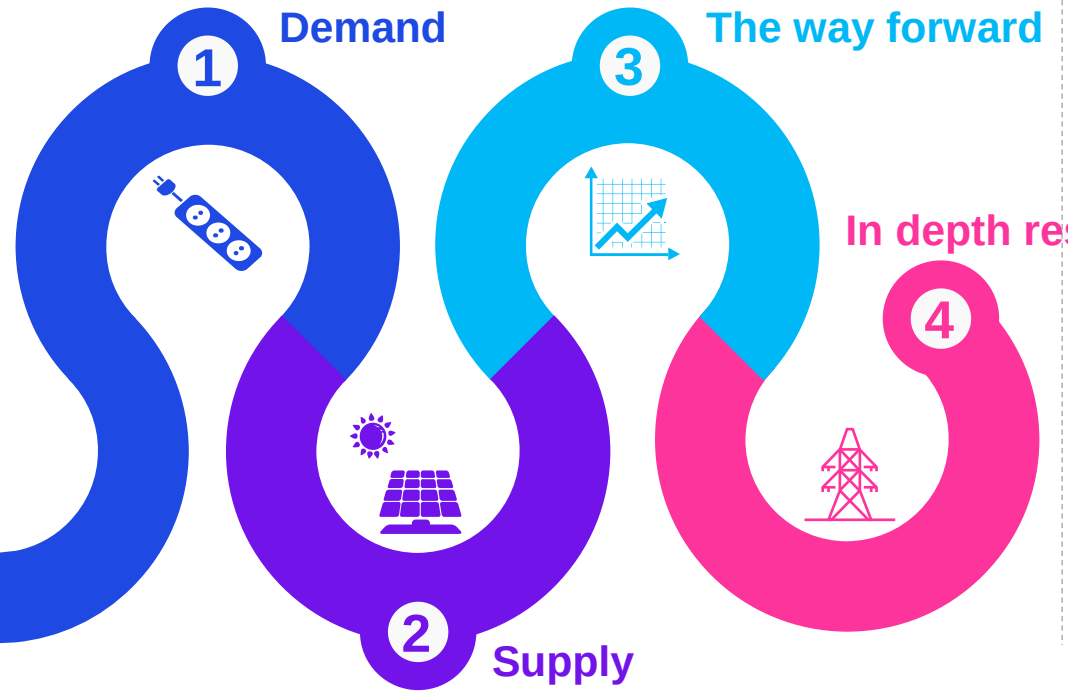
Electrification of light/medium vehicles with the simultaneous development of charging networks. A substantial portion of the necessary investments will be allocated to both vehicle electrification, including battery development, and the expansion of charging networks with dynamic pricing capabilities.

**Source:** Draft 2023 Greek NECP

# Survey objectives

Our analysis in this report spans a wide spectrum. We scrutinize the historical evolution of the Greek electricity market, dissecting its structural components and market dynamics. We delve into the current state of affairs, examining energy production, consumption patterns, pricing elements and market participants.

The primary objectives of this report are to provide a comprehensive diagnosis of the Greek electricity market, identify bottlenecks and opportunities, and present a roadmap for sustainable and resilient energy development. Our aim is to equip policymakers, industry stakeholders, investors, and citizens with the knowledge and insights needed to navigate the intricate energy transition landscape.




### Demand

This section examines the evolution of electricity demand/ consumption per sector, fuel and voltage type. Pricing considerations, evolution of end-user prices and decomposition of the final prices. Finally, demand is being examined also from a macroeconomic point of view, providing insights of consumption per capita, vs private income, vs value added and more.

### Supply

The second chapter covers the Supply side through understanding the full Electricity Value Chain, providing a high level comparative analysis of key players, their financials and market share evolution. The historical growth of generation mix per fuel type (capacity and energy) along with known targets and developments are also examined. Finally, a presentation of the wholesale market pricing evolution explaining the main drivers behind its recent increase are presented.

### The way forward

This part of the survey focuses on the main challenges that lie ahead for the Greek electricity sector along with the main opportunities that could potentially be exploited.

### In depth research: The importance of interconnection to Central Europe

The last part of the survey presents an in depth look in the development of the Greek energy system due to the operation of a new 9 GW electricity corridor to Germany. The study identifies potential benefits that the interconnection can entail for both end-consumers as well as the national economy. Additionally, this study aims to capture the inherent market operation dynamics and, therefore, provide long-term market indicators.

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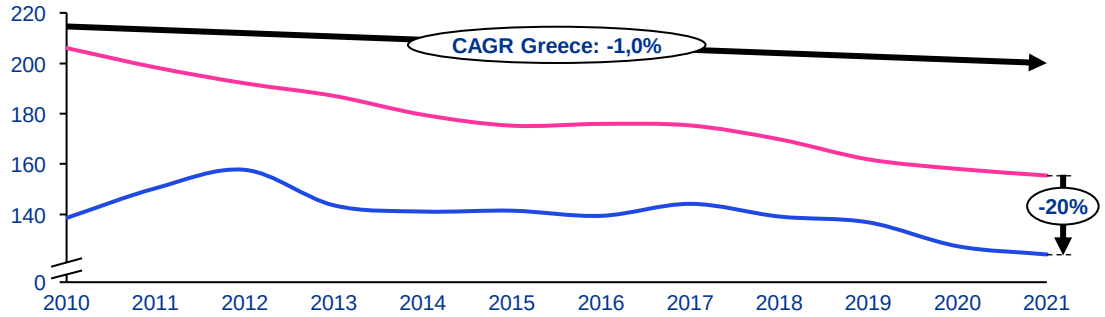
# From a macroeconomic point of view, Greece follows similar pattern compared to EU in energy intensity and electricity consumption

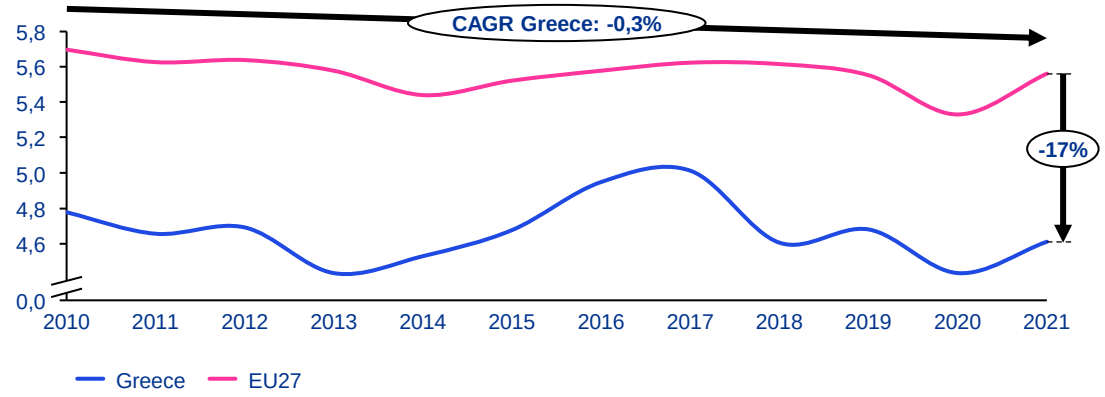
## Energy intensity of the economy (in kgoe per '000 Euro)[1]




If an economy uses less energy per unit of GDP, it is considered more energy efficient. In practice, however, this relationship is more complex, as energy intensity is affected, among other factors, by the structure of an economy, structural changes, technological development, climate, and many other factors. This is the case beyond 2010, and more specifically in the 2012 peak where the main driver was the significant decrease of the GDP.

Overall, from 2010 – 2021 energy intensity has decreased by 11% (or 1% per annum) reaching the lowest level of this time frame. This is mainly attributed to the efficiency improvements in technology and infrastructure sector, the changes in the consumption behavior and the GDP growth.

## Gross electricity consumption per capita (in MWh per capita)



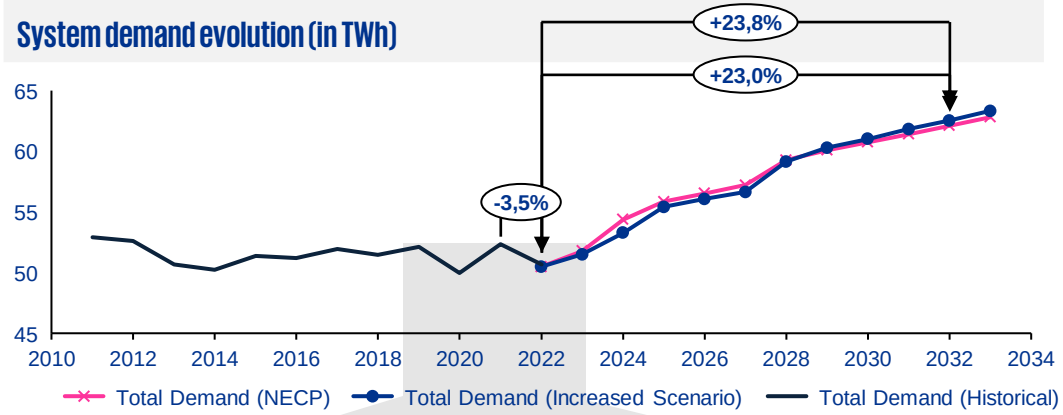

From 2010 – 2013 the decrease in electricity consumption per capita was driven by the financial crisis that heavily affected Greece. Additionally, the drop noted in 2020 is due to the Covid – 19 pandemic.

It is expected that from 2025 onwards electricity consumption will increase, mainly driven by the recovery of the economic activity, which was affected by the pandemic and the energy/financial crisis of 2021-2023, as well as the intensified electrification of end uses.

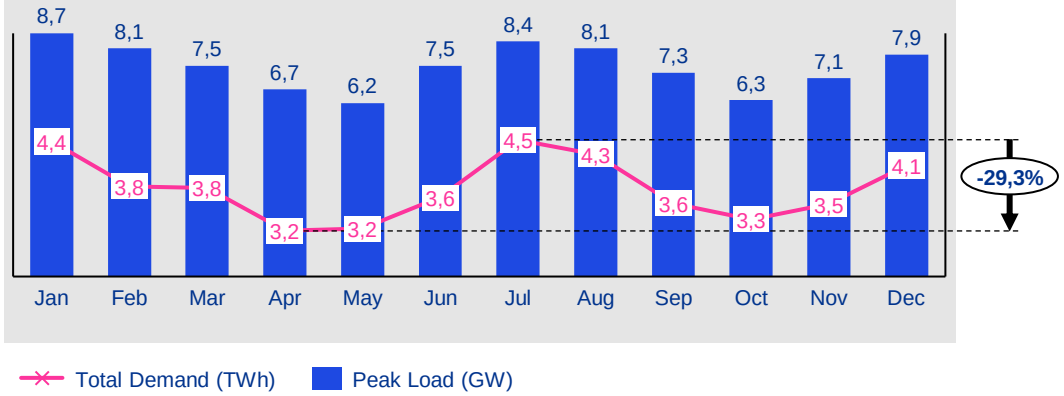
**Sources:** Eurostat, KPMG analysis **[1]Note:** Gross available energy divided by GDP

# Electricity demand is expected to significantly increase, as a result of EU policies that incentivize further electrification

## System demand evolution (in TWh)




## 2018-2022 monthly average (demand vs peak)[1]



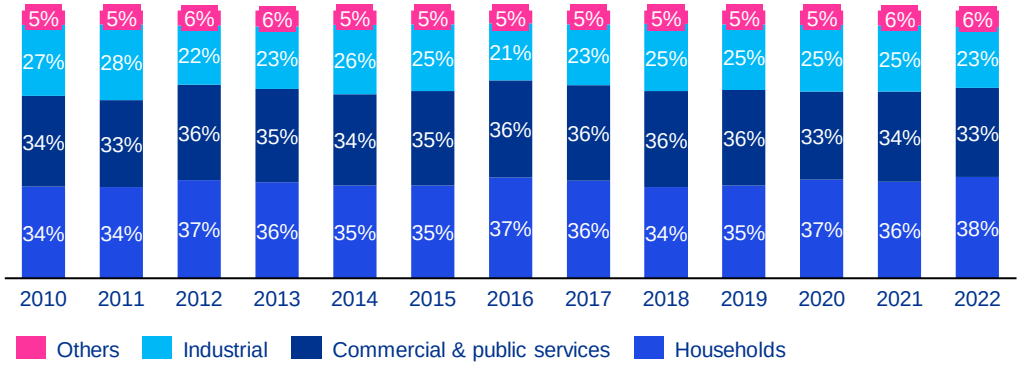

**Sources:** Eurostat, IPTO TYNDP 2024-2033 draft, IEA, KPMG Analysis **[1]Note:** System load curve includes HV demand, mining, power plants' self-consumption, network demand (MV, LV), grid losses and Crete interconnection

In 2022 a drop in electricity consumption was noticed in Greece. This was attributed to the mild winter, as well as the skyrocketing of the energy prices. Economic slowdowns and high electricity prices stifled electricity demand growth in most regions around the world. According to IPTO's TYNDP, the evolution of the system demand (projections to 2033) is mainly attributed to the electrification of the transport sector along with the expected interconnection of the (currently) non-interconnected islands.

Greece's electricity load curve presents seasonal highs in winter (Dec-Jan) and summer (Jul-Aug) period. The increased consumption during winter is driven by households' heating needs, while during summer period the peak in load is due to the increased touristic activity and the hot temperatures that require additional cooling needs, both for comfort but also for industrial uses. During the last 5 years, the highest demand was recorded in August 2021 at 9,4 GW

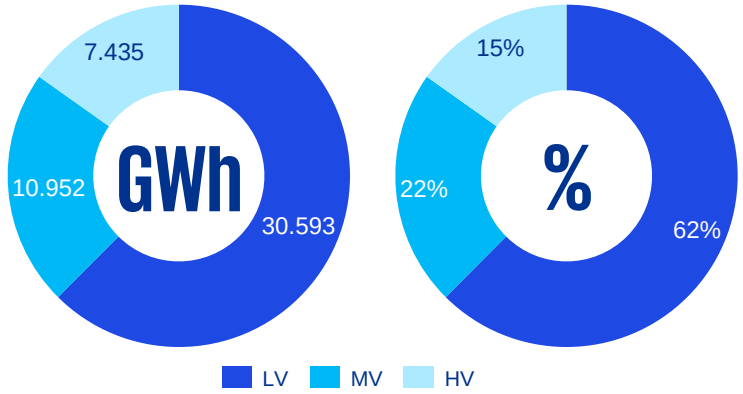
Historically, residential and commercial-public sector comprise ~70% of total electricity consumption of Greek market.

## Share of electricity consumption by sector

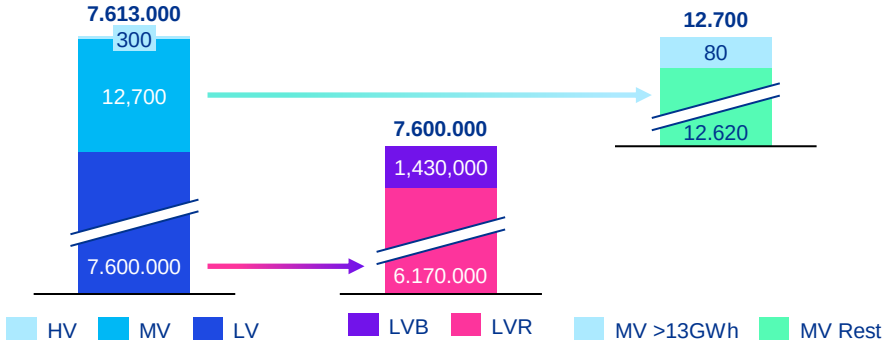


# Low Voltage consumers dominate the electricity demand both in total volumes and number of meters

## Electricity Consumption[1] for 2022 per voltage level

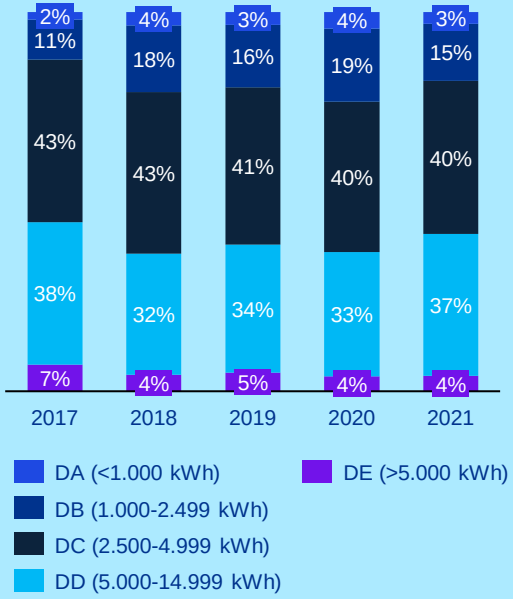



## Estimated number of meters per voltage level and sub-category



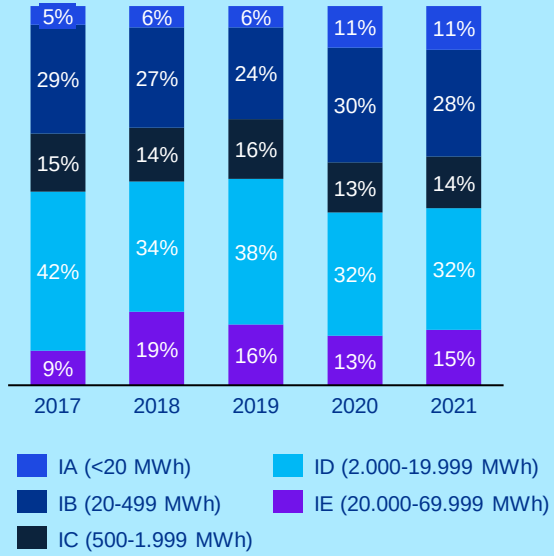

## Electricity demand in households per consumption band[2]

The largest percentage of consumption falls under band **DC (2.500-5.000 kWh)**




## Electricity demand in non-households per consumption band[3]

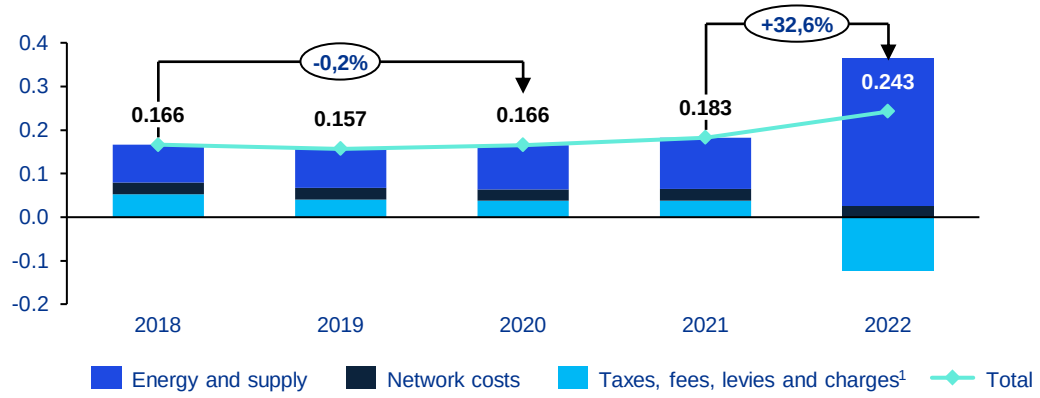
The largest percentage of consumption falls under band **ID (2.000-20.000 MWh)**



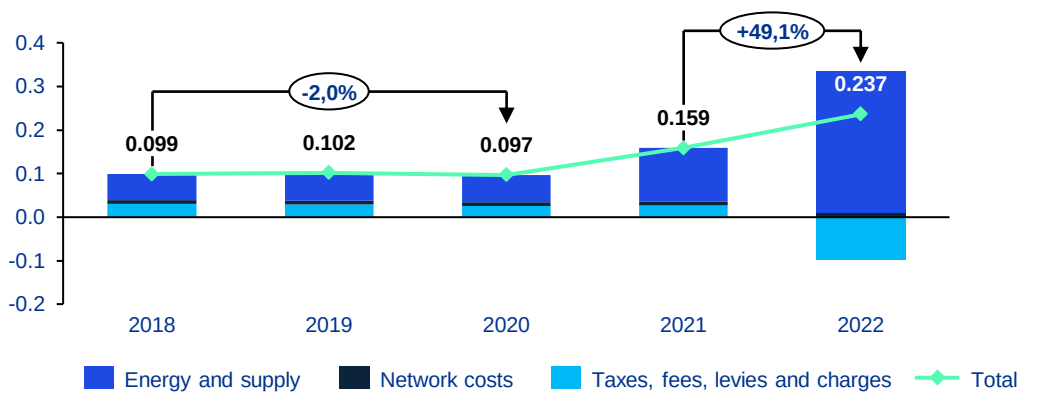

**Sources:** Eurostat, IPTO, HEDNO, KPMG Analysis **[1]Note:** Consumption refers only to the Interconnected System **[2]Note:** Bands as defined by Eurostat **[3]Note:** No available data for IF and IG (confidential data)

# The energy crisis since 2021 has significantly affected end-user prices, with State intervention being a key decision

## Household electricity price – DC band (€/kWh)




## Non household electricity price – ID band (€/kWh)

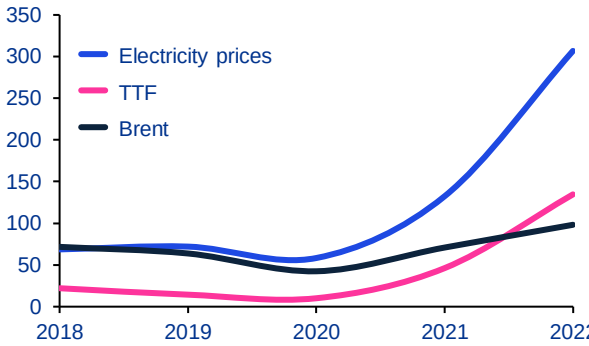



Electricity retail prices were historically consistent in the Greek market until 2021, with minor deviations in end-user prices year over year.

The **skyrocketing of natural gas prices since 2021,** with one of the drivers being the Russian-Ukrainian war, led to an **increase[2] of up to +266% in households and +421%[3] in non-household** upfront prices. Electricity prices for non-households consumers were traditionally lower, in nominal terms, compared to households consumers. However, they are currently subject to **higher increases** leading to approximately similar final prices.

**Government subsidies**, initially, as well as the **application of a windfall profit capturing mechanism**, resulted in a normalization of this effect to end-consumers managing to moderate the **overall increase to +32.6% for household and +49.1% for non household** electricity price.

## Electricity prices vs TTF and Brent (in €/MWh)




Electricity prices in Greece are highly correlated to Natural Gas TTF prices with a correlation factor of **0.985**

**Sources:** Eurostat, KPMG Analysis, **[1]Note:** Taxes, fees, levies and charges include Value Added Tax (VAT), Renewable taxes, Environmental taxes and other fees/subsidies **[2]Note:** 2022 vs the average of 2018-2020 **[3]Note:** all comparisons refer to the selected consumption bands i.e. DC and ID

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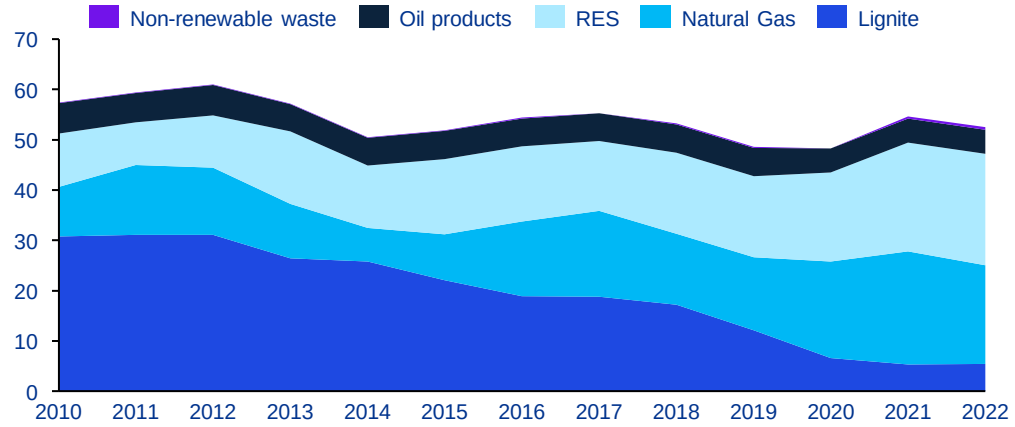
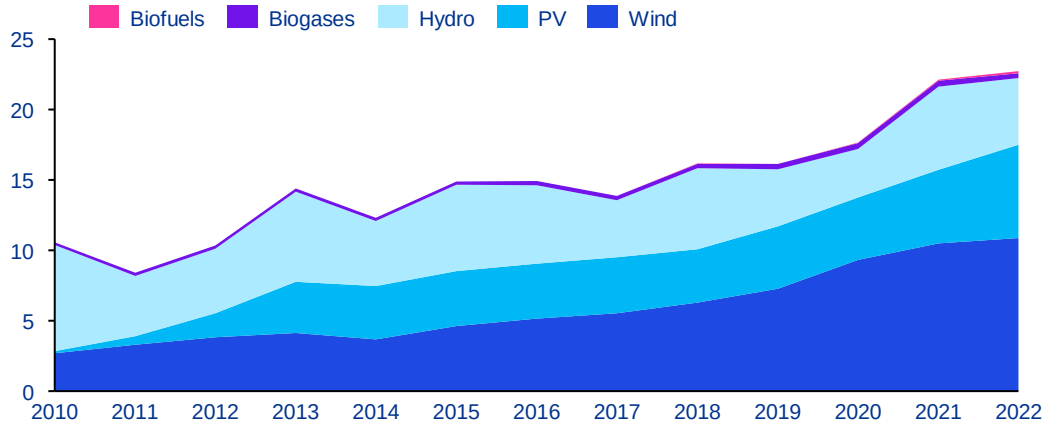
# The share of RES in the mix is constantly rising

## Electricity generation by fuel type (in TWh)



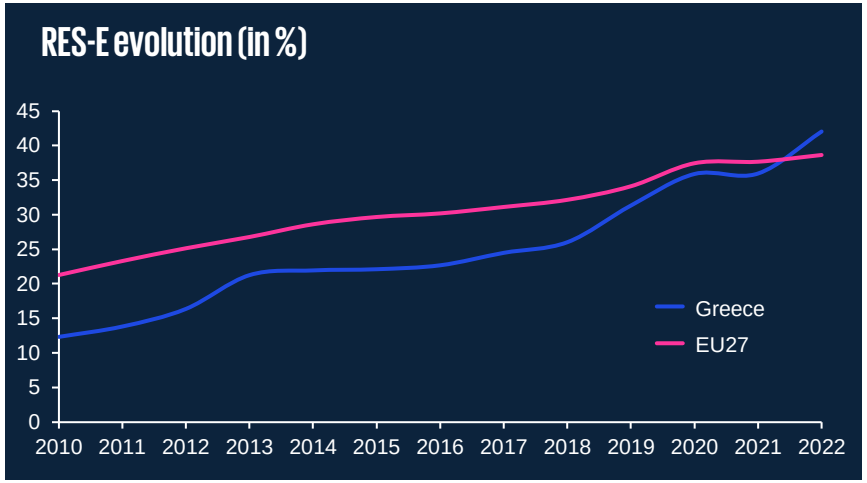

## Electricity generation of RES by type (in TWh)




- Greece's renewable energy strategy strives to expedite the adoption of renewable sources. The government perceives renewable energy as crucial in meeting the 2030 climate objectives and realizing the long-term ambition of achieving net zero emissions.
- RES use in the electricity generation increased more than any other fuel from 2010-2022, taking share from the reduction in the use of lignite.
- In 2022 RES (including hydro) comprised **~42% of total generated electricity (vs 9% in 2007)**, while in 2019 and 2022, **RES was the leading fuel** for electricity generation (16,1 and 20TWh respectively) surpassing both natural gas and lignite.
- Moving towards 2030, a huge increase in the participation of RES is expected (>80% of total generation vs 67% of the 2019 NECP) in the generation mix. This development will be also supported by the phase-out of all lignite plants by 2028, special incentives for roof PVs and further development of energy communities.

**Sources:** Eurostat, Ember, IPTO TYNDP 2024-2033 draft, Draft 2023 Greek NECP, KPMG analysis

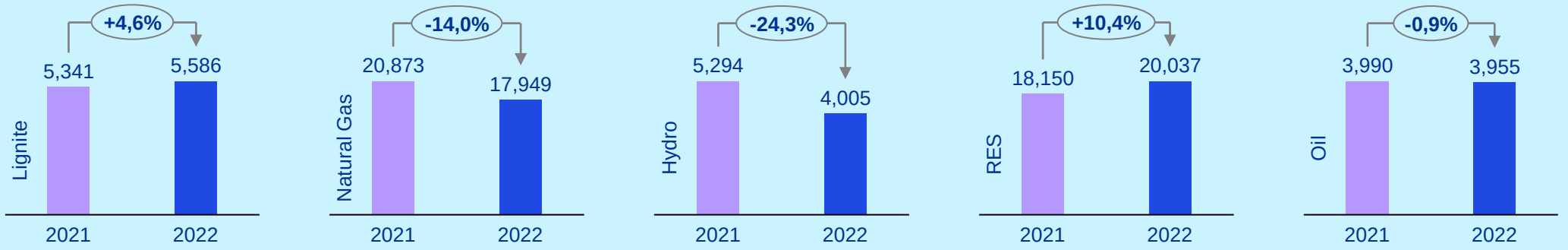
# 2022 revealed a slight uptake of lignite production and a significant increase in solar generation




## In 2022, the total generation, including non-interconnected islands, reached 52 TWh, making a 4% decrease compared to the generation of 2021

- Natural gas share was reduced compared to 2021, among others as a reaction to the dependence reduction on Russian fossil fuels.
- Lignite regained share in the generation mix since the record-high gas prices made lignite variable cost competitive again.
- Hydro share was reduced in 2022 due to insufficient water availability.
- RES share is constantly increasing surpassing the EU27 average for the first time in 2022.

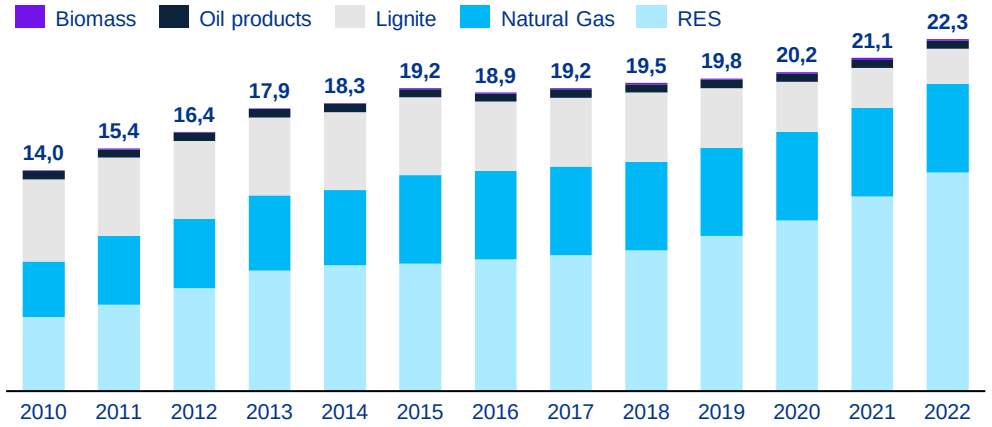
## Generation by source (GWh)



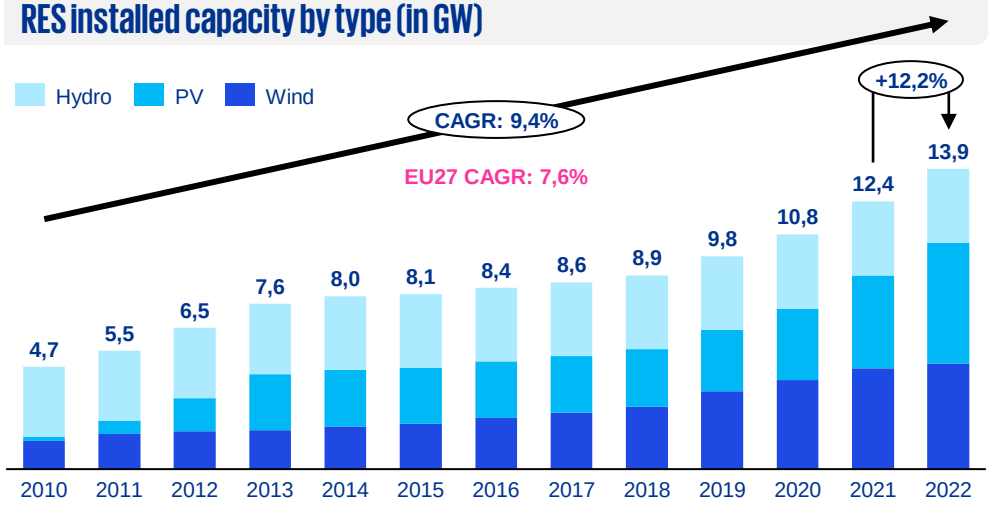

**Sources:** Eurostat, IPTO, HEDNO, KPMG Analysis **[1]Note:** Oil generation as published from Non-Interconnected Islands HEDNO reports, **[2]Note:** RES generation also includes volumes from Non-Interconnected Islands HEDNO reports

# Wind and solar developments dominate the transformation of the energy system

## Installed capacity by fuel type (in GW)



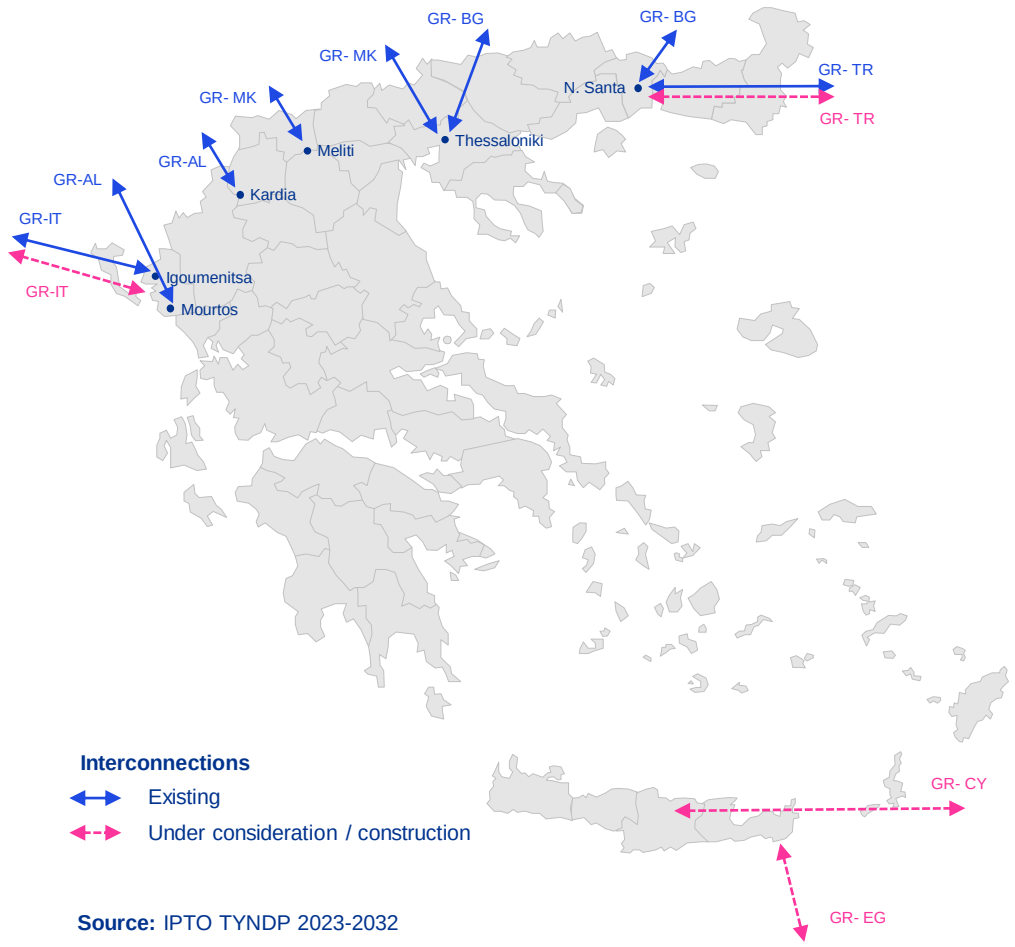

## RES installed capacity by type (in GW)




- During the last 5 years, 4,9GW of additional RES capacities have been installed, leading in to a **55% increase compared to 2018** (EU27 average at 34%). During the same period, solar show an annual increase rate of 20% while wind 14%. New hydro development is limited as the usable sites are subject to saturation.
- Since 2018, 2,2GW of lignite capacity has been decommissioned, namely PPC's Kardia 1-4 and Amyntaio 1-2.
- Breakthroughs are expected to occur in the current decade in the field of power supply in Greece, as the RES share in power generation is expected to increase significantly and gradually replace the use of fossil fuels. Although in the 2019's NECP the lignite phase-out was scheduled by end 2023, the Russian-Ukrainian war changed the framework and with the very recent new climate law the new deadline for the lignite phase-out was extended to end 2028.
- High penetration of RES **require energy storage** for sufficient take-up of the energy generated by such. The development of storage systems will support RES penetration and provide flexibility and ancillary services in the System. Additionally, **grid developments** to accommodate and effectively integrate such technologies into the energy system will be highly needed, both internally and externally (i.e. interconnection with other countries).

**Sources:** IPTO, HEDNO, Ember, KPMG analysis

# Being historically an importing country, Greece focuses on strengthening its interconnections with neighboring countries




**Source:** IPTO TYNDP 2023-2032

The interconnections with the neighbor countries take place via 400kV AC lines (exception is Bistrica – AL which is 150kV)

The interconnection with Italy is made through an underwater DC connection. The construction of the second interconnection to Italy (1.000MW) is still under consideration as the study for the optimal technoeconomic option has not been finalized.

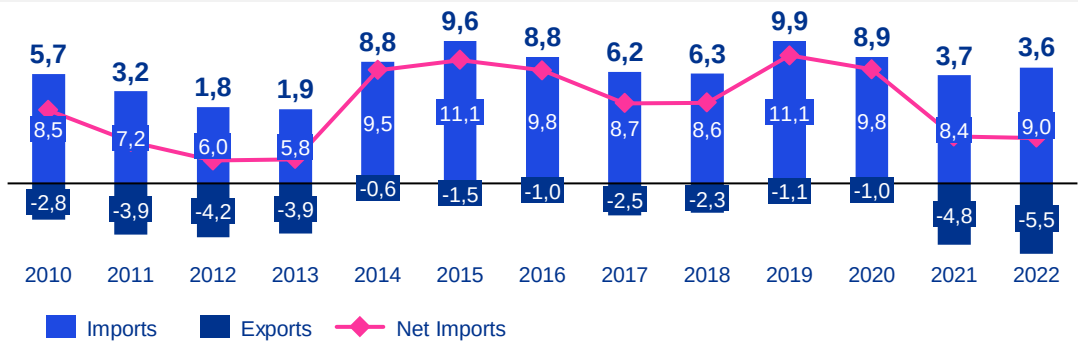
The interconnection of 130km between N. Santa and Maritsa (GR-BG 1.100MW) was completed in summer 2023.

The interconnection of transmission systems Greece - Cyprus will take place with DC connections (1.000MW) and it is expected to be completed between 2026-2028.

The second interconnection to Turkey (600MW) is expected to be completed by 2029.

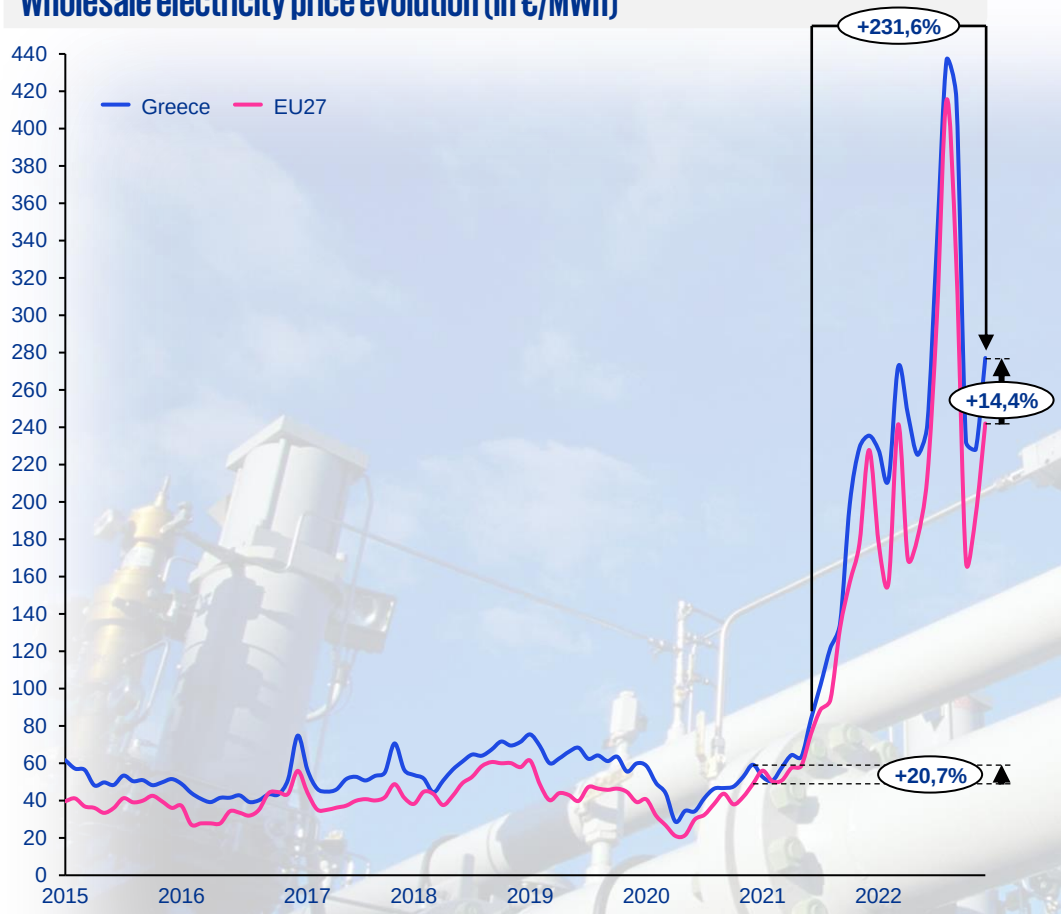
A new interconnection line with Egypt (3.000MW) is also under consideration by IPTO and – if constructed – is expected to operate from 2027 onwards.

## Historical electricity imports and exports (in TWh)



# Greece is traditionally among the top-5 most expensive countries when it comes to electricity wholesale prices

## Wholesale electricity price evolution (in €/MWh)

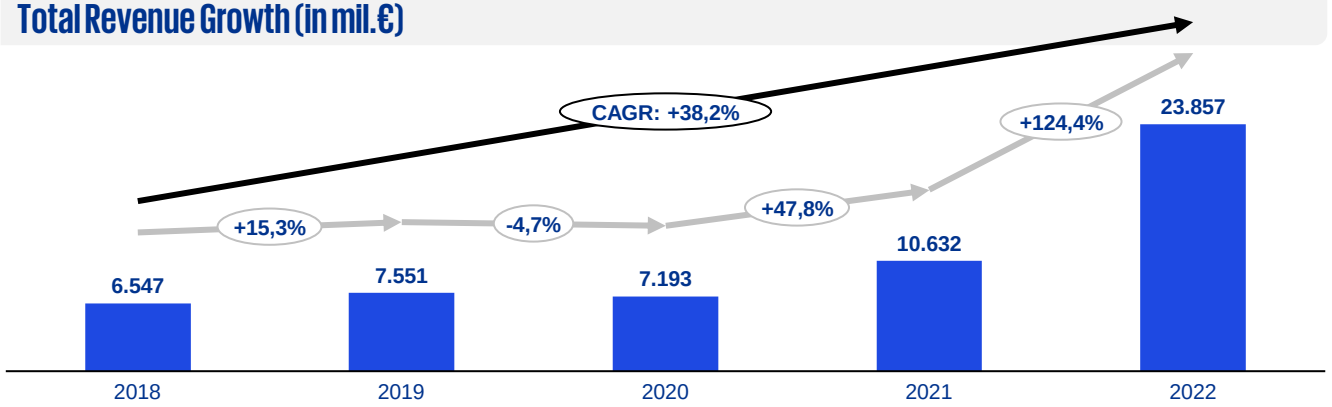



**Sources:** IPTO, HEDNO, Ember, IEA, KPMG analysis

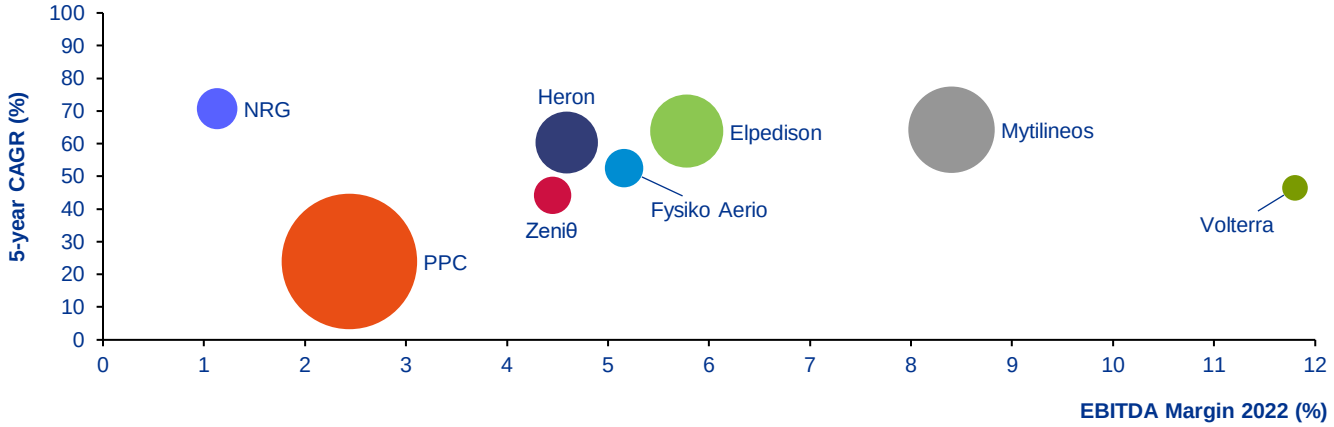
- The worldwide energy crisis, characterized by escalating energy commodity costs coupled with the post-pandemic economic recovery and supply chain challenges, has led to significantly elevated wholesale electricity prices in numerous global regions in 2022 compared to the previous years.
- Prices reached unprecedented high level across Europe, due to the uncertainty of the markets around European security of gas supply and the role of gas prices on wholesale electricity markets (Nord Stream 1 cut-off), the geopolitical invasions (Russia – Ukraine) as well as the weak hydroelectric power production due to droughts.
- New emergency intervention policy measures were introduced to tackle high electricity prices, including demand reduction measures and a temporary revenue cap on inframarginal electricity producers.
- Greek market prices are mainly driven by the gas prices (i.e. TTF, LNG) which are responsible for more than 80% of the total influence.
- Notable countries at the EU for high prices are Italy, Slovenia, Hungary Croatia and Romania, while at the other end Sweden, Finland and Poland keep their wholesale market prices way below the EU average.
- Although by comparing the clearing prices might seem that Greece is close to the EU average, the true impact to end-consumers is much worse: Greece reflects the wholesale prices (as cleared in the Energy Exchange) almost completely to consumers while in many EU countries the final price to end-users is very little affected by the marginal, expensive generation units. This is attributed to the fact only a small portion of the generated electricity passes through the power exchanges which are mainly used to cover other types of services such as balancing needs.

# There is a significant growth of the energy market over the past 5 years revealing a compounded annual growth of 38,2%

## Total Revenue Growth (in mil.€)




## Key Players Profitability 2022




— In 2022, the significant market growth is attributed to **the skyrocketing of energy prices.** Price effect and volume effect were acting opposite to each other: electricity demand decreased by 3,5% while at the same time wholesale market prices showed an increase of 132% compared to 2021.

— In 2021, the significant increase is attributed to both volume and price effect: electricity demand increased by approx. 5% while at the same time wholesale market prices showed an increase of 127% compared to 2020.

— The Top8 players in the electricity and gas sectors in Greece generated almost € 24 billion in 2022[1], increased by 124% compared to 2021.

— 2020 was affected by the Covid-19 pandemic and the overall decrease of electricity demand.

— PPC leads the market with a turnover of €10,8 billion in 2022 vs €5,4 billion in 2021. Mytilineos[2] and Elpedison follow with €4,4 and €3,2 billion respectively.

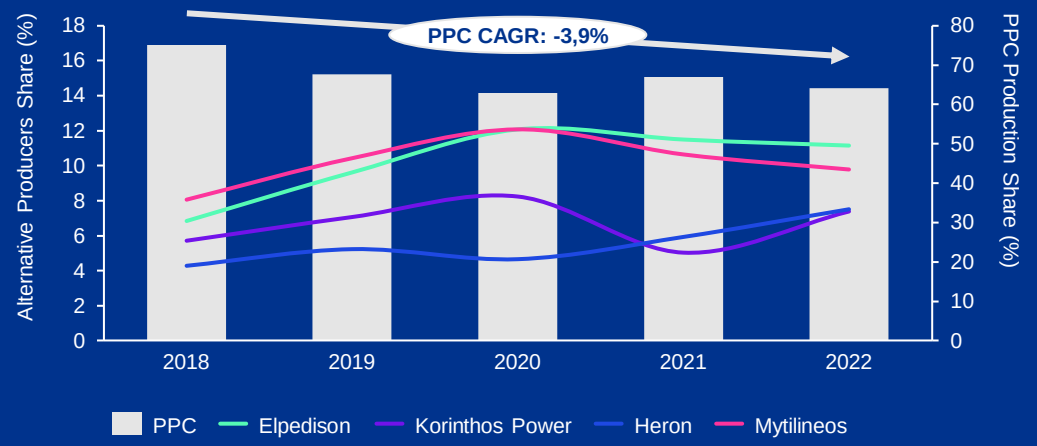
— Volterra and Mytilineos achieved the highest EBITDA margins in 2022.

— NRG shows the largest annual increase rate for the period 2018-2022 at the levels of 71%.

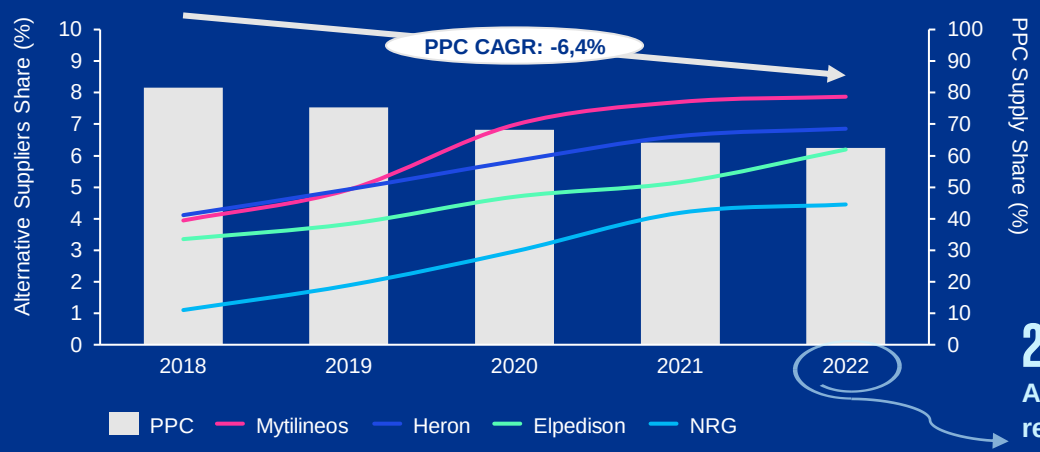
**Sources:** KPMG Analysis, **[1]Note:** W+V and Volton are not included since the Financial Statements for 2022 were not published during the preparation of this study, **[2]Note:** Mytilineos financials refer to the Power & Gas sector

# PPC remains the leader in both conventional generation and supply, however competition steadily gains market share

## Conventional Generation Market Share[1] (in %)




## Supply Market Share[1] (in %)




**26**
**Active retailers in total**

PPC is the largest electricity producer averaging 67,7% of the total generation[2] for the period 2018-2022.

Mytilineos and Elpedison are hand-to-hand in the generation[2] market with a 5-year market share of 10,1%.

Korinthos Power owns a CCGT unit of 437MW and is a subsidiary of Mytilineos, with Mytilineos holding a 65% ownership stake, while Motor Oil owns 35%. It is located in Motor Oil's refinery in Korinthos.

PPC is constantly reducing its market share in the supply sector.

From the top 5 suppliers of the period 2018-2022, NRG shows the highest annual increase rate of 40,8% in the supplied volumes[3]. Mytilineos and Elpedison follow with a CAGR of 18,2% and 15,9% respectively while Heron grows with a CAGR of 13%.

Mytilineos announced the acquisition of W+V in August 2022, leading to an addition of approx. 200.000 customers in its portfolio. The company has also proceeded to the acquisition of Volterra in August 2023. The combined market share is expected to exceed 13%.

**Sources:** IPTO, KPMG Analysis, **[1]Note:** market shares have been calculated as the participant's generated/supplied annual volumes divided by the total generation/supply, **[2]Note:** refers to conventional generation (lignite, hydro, gas) in the interconnected system, **[3]Note:** refers to supplied volumes in the interconnected system

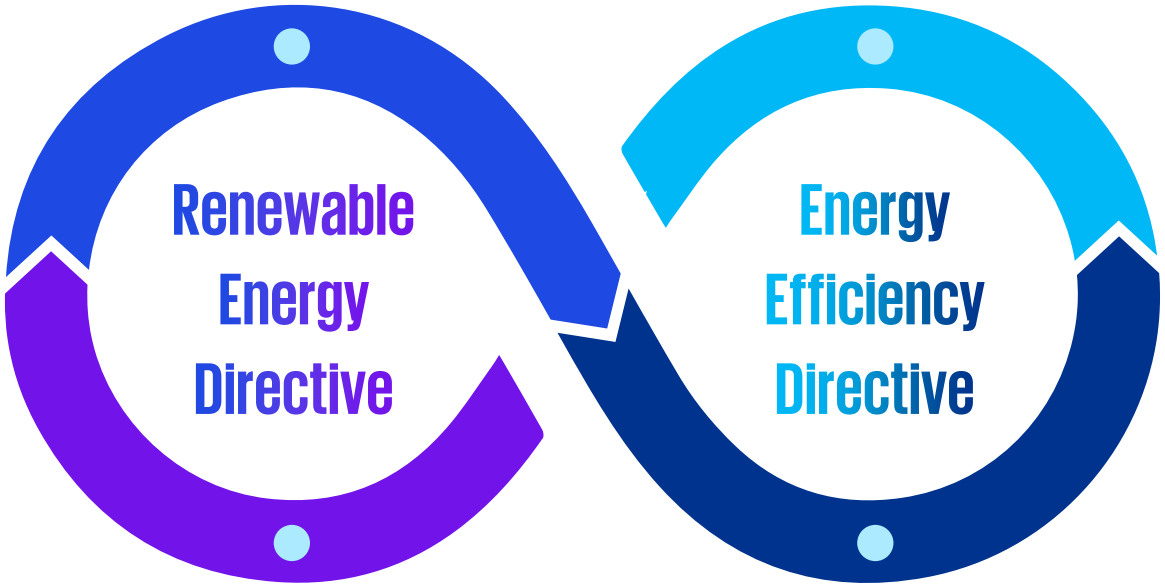
# Contents

# By 2050, Europe aims to become the world's first climate-neutral continent

To pave the path to meet this aspiration in the fight against climate change, the European Commission (EC) released the "Fit for 55" package, which contains ambitious climate targets. Specifically for the energy sector, two major existing energy directives have been amended, and together, they aim to increase the share of renewables in energy mix and meet enhanced energy efficiency targets via integrated energy systems.

**Under the new RED II directive, innovative measures are set to be implemented to capitalize on every conceivable opportunity for renewable energy development.** These measures encompass:

- Establishing specific targets for renewable energy adoption in transportation, heating, cooling, buildings, and industry. There will be a shift from conventional renewable sources like solar and wind to explore newer energy forms such as hydrogen, biofuels, and other renewable fuels.
- Incorporating certain concepts outlined in energy system integration and hydrogen strategies into EU law. For instance, the notion of an integrated energy system will be legally defined.
- Changing the stance on biomass use, particularly wood, which will no longer receive support from the EC. Instead, specific prohibitions on national incentives will be introduced.
- Facilitating renewables deployment by eliminating obstacles in permitting processes and Power Purchase Agreements (PPAs). Member states will collaborate to enhance the development of guarantees of origin, streamlining the transition to renewable energy sources.




**The EED revision includes the following:**

- Stepping up actions and addressing gaps for energy efficiency
- Reviewing the adequacy of the directive and accounting for the higher climate target and recent
- Commission initiatives, such as the Energy System Integration Strategy
- Implementing the energy savings obligation for the 2021–2030 period
- Revising metering and billing provisions for thermal energy
- Improving efficiency in heating and cooling.

**Sources:** KPMG European Green Deal policy guide

# Greece's efforts aim to guarantee energy security, enhance economic competitiveness, and safeguard vulnerable consumers

In the future, Greece's energy policy aims to enhance the utilization of renewable energy, particularly for electricity generation. This strategy is coupled with efforts to expand the portion of energy demand met by electricity, especially in the realms of transportation and heating and cooling. The following priorities should be taken into consideration by the Greek Government:


## Fossil Fuels

Review the necessity of investments in fossil fuel infrastructure, considering the risk of stranded assets and the imperative to allocate limited capital to investments that promote the energy transition.


## Regulation and Legislation

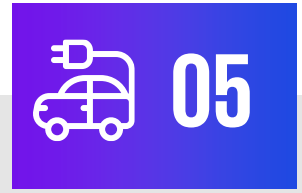
Establish clear and consistent legal and regulatory frameworks that facilitate the timely implementation of renewable energy and electricity infrastructure projects. Simplify spatial planning and licensing procedures to expedite project deployment.


## Financial Support

Re-assess taxes, market regulations, and financial support measures to incentivize behavior and investments aligning with a fair energy transition. Encourage increased system flexibility and mitigate the risk of stranded assets by aligning energy prices with these objectives.


## Energy Savings

Prioritize building renovation initiatives that emphasize comprehensive improvements, integrating thermal insulation with heat pumps for optimal energy savings and reduced bills. Ensure vulnerable households are given precedence and sufficient resources in these efforts.




## Vehicles

Encourage the replacement of old vehicles by offering incentives allowing the exchange of older vehicles for more efficient ones. Several initiatives have already been made to promote purchasing of EVs, expanding charging infrastructure and incorporating electric buses in the public transportation.

**Sources:** IEA, KPMG Analysis

# Modernizing the grid to accommodate increased RES capacity, manage storage, and enable efficient transmission across borders is complex

Greece's energy landscape is evolving, demanding a responsive and resilient electricity grid. Upgrading the grid is not just a requirement but a strategic investment vital for Greece's sustainable energy future.

## 01
## Rising Demand

Increased demand necessitates grid expansion to accommodate growing load and new consumption patterns, especially in urban centers and industrial zones.

According to IPTOs 10-year plan, electricity demand is expected to increase from 22,5% - 32% (2 scenarios) as a result of the economic activity growth, interconnection of islands and EV penetration.

Integrating energy storage solutions such as batteries and pumped hydro storage enhances grid flexibility, allowing for the efficient storage and release of excess energy during peak and low-demand periods.

## 02
## RES Integration

A modern grid is essential to effectively incorporate renewable sources like solar and wind, ensuring efficient energy distribution and storage capabilities.

## 03
## Smart Technologies

Implementing smart grid technologies enables real-time monitoring, efficient load management, and rapid response to fluctuations, enhancing grid flexibility.

Smart technologies, demand response programs, EV chargers, and decentralized energy systems require an intelligent grid capable of managing complex interactions efficiently.

Such projects increase the flexibility of the Hellenic Electricity Transmission System and contribute to the export orientation of the country in terms of renewable electricity generation. Additionally, developments of cross-border transmission lines support the EU Market integration as well as contribute to the security of supply.

## 04
## Cross-border Exchange

Greece, with its potential for renewable energy generation, can export clean energy to neighboring nations, contributing to regional sustainability goals and facilitate investments.

# Outdated grid infrastructure and lack of advanced metering systems can hinder the effective implementation of demand response programs

**Demand response can serve as an extra resource of balancing, lightening the burden of conventional generation units and storage by aligning the demand with the variable RES generation. Additionally, by reducing the consumption during high demand periods, DR can help prevent grid overload and potential blackouts while on the same time avoids peaker plants and thus reduces costs and emissions.**

## Opportunities

- New digital technologies can help to automate demand response through connected devices and harness the growing potential of distributed energy resources, such as smart meters, building energy management systems, eMobility (Vehicle to Grid) and more.
- The European Union approved an action plan in October 2022 for digitalizing the energy system, which includes establishing requirements and procedures to facilitate data access for demand response. In parallel, the EU electricity market design proposed reform is under discussion with an aim to introduce measures to support low-carbon flexibility solutions in the market, including demand response.
- Since June 2022, IPTO has launched a test demand response platform for the potential stakeholders in order to proceed with the registration and familiarize with the tool and the overall demand response framework.

## A series of decisions and actions enable the realization of Demand Response in Greece

- Demand Response is a brand new concept for the Greek market. Not only from the servicers perspective – where they need to carefully design their approach to the end-users, business strategy and day-to-day operation – but also for the consumers. Limited awareness among consumers about demand response benefits and methods may pose a challenge in encouraging widespread participation.
- Participation in demand response schemes should gradually cover not only large industrial consumers, but all consumer types, whether individually or through aggregators. However, significant amount of residential's load will remain unexploitable due to the delay of smart meters' roll out
- Handling consumer data securely while implementing demand response strategies is a significant concern and challenge that needs careful management.

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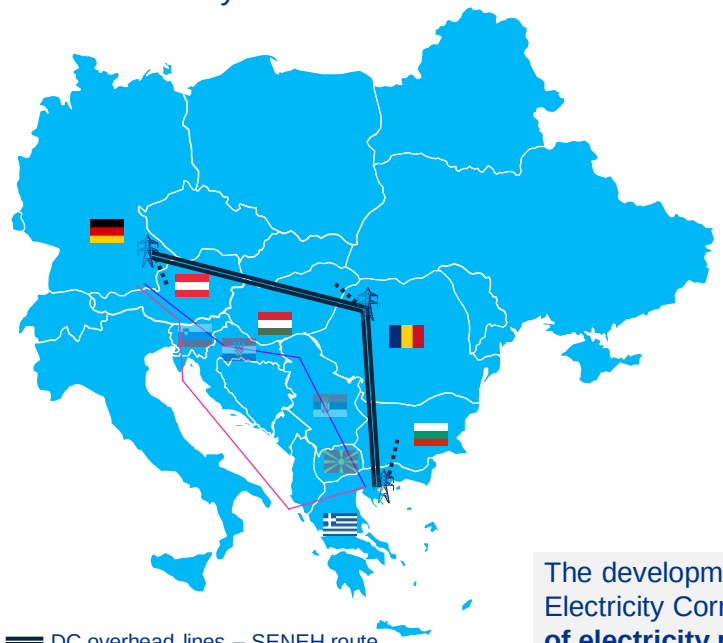
# A new 9GW link to Germany can exploit Greece's untapped RES potential and is aligned with EU strategic targets

KPMG, in collaboration with the Aristotle University of Thessaloniki and the School of Electrical and Computer Engineering, have assessed the potential benefits from the operation of **a new 9 GW green electricity corridor to Germany**.

Various parameters were analyzed to formulate 3 long-term electricity market simulation scenarios. The ultimate goal of this analysis was to estimate the total cost of electricity supply to be undertaken by the end-consumers along with the cost/benefit of the national economy associated with the cross-border electricity.



DC overhead lines – SENEH route
AC connections
DC/AC terminals
Alternative route 1
Alternative route 2

## Sc.1

- **Four (4)** New CCGTs (Average UCAP ≈ 800 MW) operate during the entire study period
- BESS penetration according to NECP assumptions during the entire study period
- The 9-GW Interconnection to Central Europe is **NOT available**

## Sc.2

- Three (3) New CCGTs (Average UCAP ≈ 800 MW) operate during the entire study period
- No BESS are considered during the entire study period
- The 9-GW Interconnection to Central Europe **is available**

## Sc.3

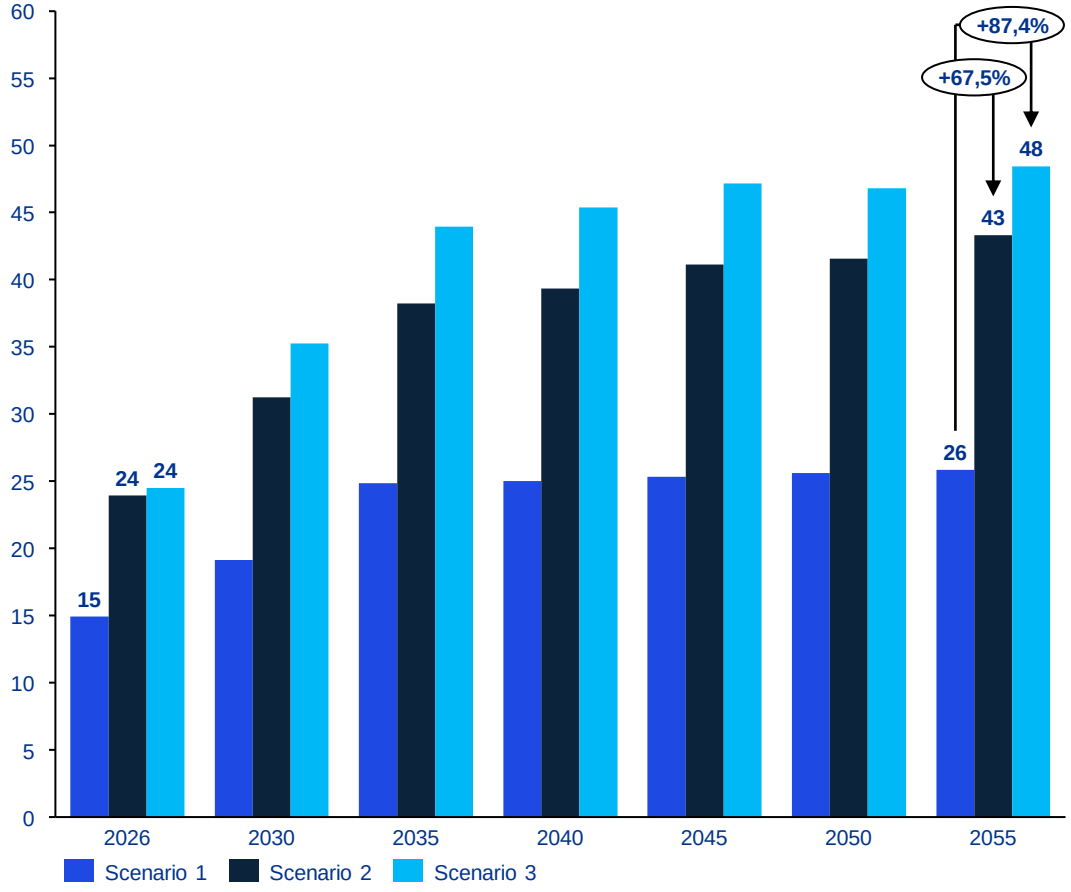
- Three (3) New CCGTs (Average UCAP ≈ 800 MW) operate during the entire study period
- Additional PV Capacity compared to scenarios 1 & 2 and moderate BESS penetration is considered to increase the annual utilization of the 9-GW Interconnection to Central Europe
- The 9-GW Interconnection to Central Europe is **available**

The development of an interconnection to central Europe could be the first electricity highway in the EU and part of the Priority Electricity Corridor of Central Eastern and South Eastern interconnections. It targets the **integration of markets**, the **reduction of electricity prices**, the **expansion of RES electricity** and EU's overall **security of supply**.

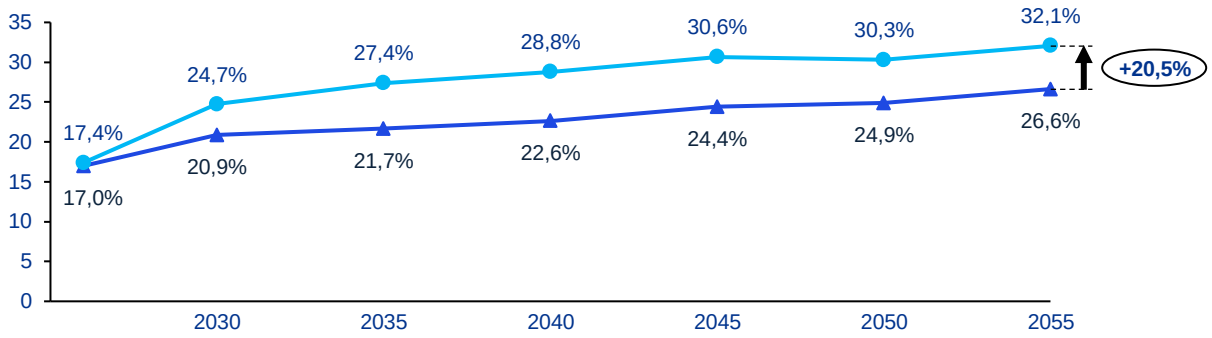
For the purposes of this study **SENEH route (South East-North Electricity Highway)** was used for the quantification of the total benefits; however, and since there are alternative routes that have been suggested during the last 2 years, the purpose of this study is not choose the exact path but rather **assess the benefits of an interconnection to Central Europe.**

# Significant economic benefits arise from the development of such infrastructure for the national economy…

## Transferred Annual Volumes[1] (in TWh)

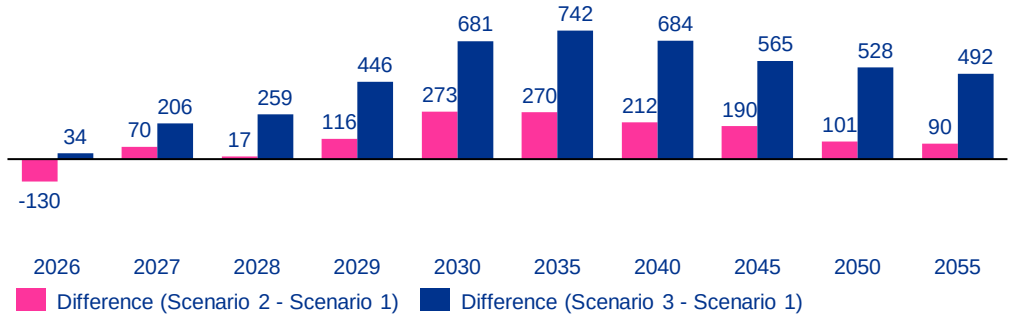



## Utilization Factor of the 9-GW Interconnection (%)




The development of the new 9 GW interconnection to Europe is expected to play a crucial role in the overall cross-border activity of Greece, projecting increased transferred volumes of +62% to +84% compared to Scenario 1. The economic benefits of such activity are significant.

## Surplus for the national economy (mil. €)

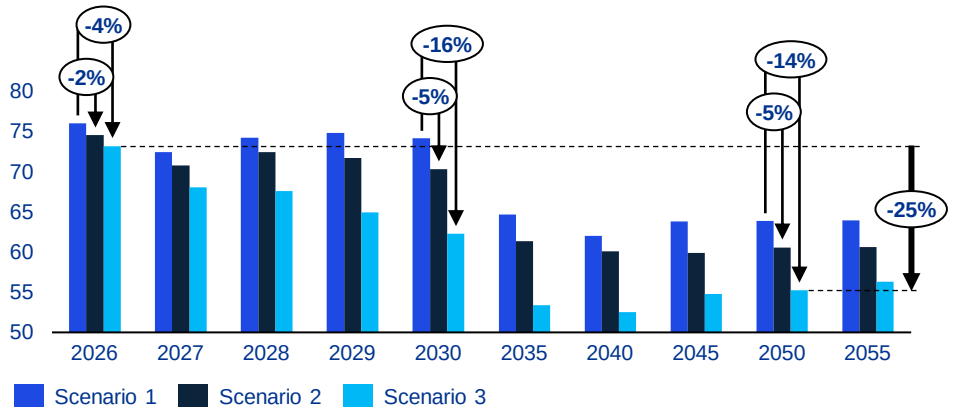



[1]**Note:** Refers to the total energy transferred i.e. imports and exports

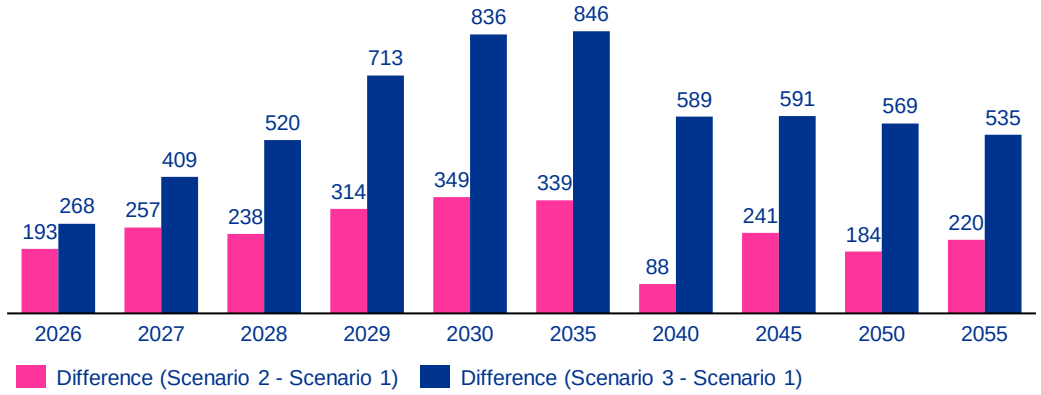
# ...as well as for the final consumers with the combined surplus for both reaching even €17,5 billion

As we move from Scenario 1 to Scenarios 2 and 3, the RES production increases meaning higher quantities of renewable energy are contractualized through PPAs and thus the blended cost for consumers (DAM + PPA price) decreases. As a result, the final prices to end-customers reach a **-4,9%** and a **-13,3% compared to Scenario 1 on average** throughout the examined period for Scenarios 2 and 3 respectively.

## Final Cost for Consumers (€/MWh)




## Surplus for consumers due to lower electricity prices (mil. €)




The analysis shows that the development of the 9GW corridor to Germany will lead to a series of economic benefits:

- A **consumer surplus** effect as a result of lower prices (final cost of electricity)
- An **additional national economy** surplus to generators as a result of the increased exporting activity

Comparing the 3 scenarios, the results show that there is a huge financial potential for both end-customers and generators. Depending on the level of RES deployment the **total benefit for the Greek economy varies from €6,2 to €17,5 billion.**

# Contents

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