ALPHA BANK

Electricity

Renewable energy sources

and the power landscape in Greece

SECTORS IN FOCUS

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Executive summary of the study

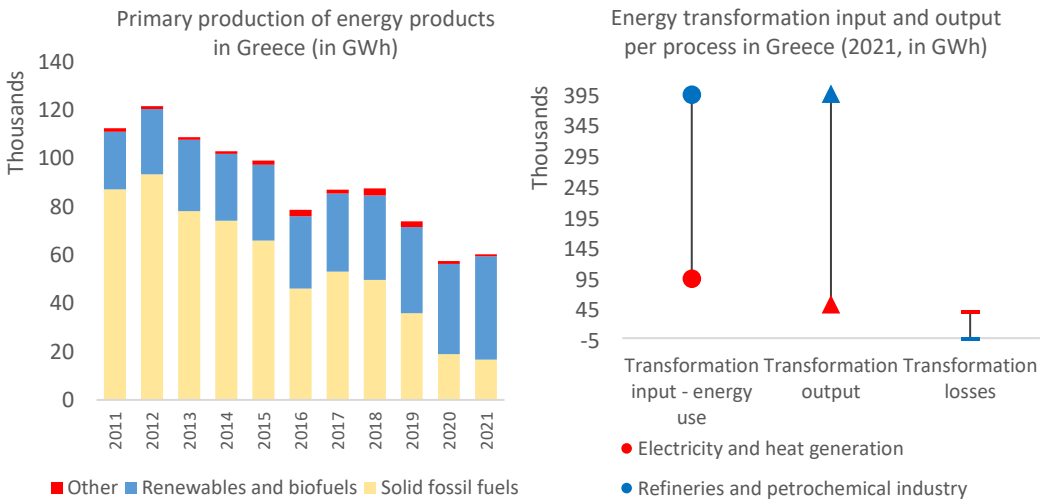
As fuel combustion remains the primary source of carbon dioxide emissions, transforming the energy and electricity landscape becomes crucial in mitigating climate change. Greece has committed to complying with this cause by aligning its national climate plans with European objectives, establishing its own targets for renewable energy integration, carbon dioxide reduction, and the gradual phase-out of lignite in electricity generation.

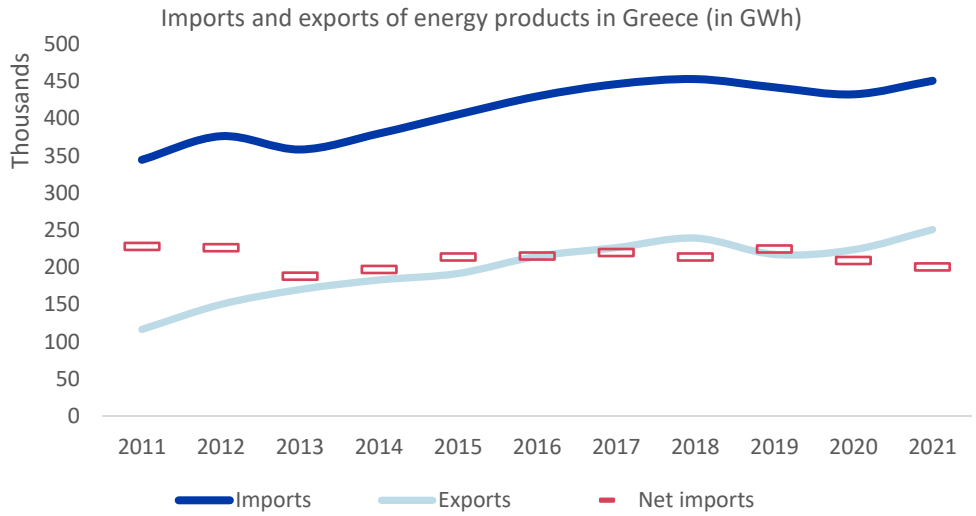
Energy transition for Greece, as evidently for many other countries, is a critical prerequisite to attaining climate targets while simultaneously improving energy security and reducing dependence on fossil fuels and energy imports. However, clean energy transition necessitates significant investments over the coming decades, not only in infrastructure but also in research and innovation, which can be supported by both the private and the public sectors.

- **Electricity is a multifaceted sector that encompasses power generation,** transmission, distribution and trade. Within the electricity sector, various companies operate as both power generators and suppliers, while other businesses have established subsidiaries or partnerships with companies operating in sectors outside of electricity.
- **PPC remains the largest electricity producer and supplier in Greece, boasting** the highest installed capacity. While PPC maintains a strong presence in the Greek electricity market, reduced shares signal increased competition and decreased market concentration.
- **The generation of electricity involves the conversion of various energy sources** into electrical energy. In 2021, Greece's total electricity production amounted to 54.7 thousand GWh, marking an 8% cumulative reduction over the decade from 2011 to 2021.
- **During 2021, the balance between electricity generated from renewable** energy sources and biofuels versus fossil fuels in Greece was approximately 40%-60%. Despite fossil fuels dominating electricity production, their share has markedly diminished over the years (from 86% in 2011).
- **Renewable energy from hydro, wind, and solar energy produced 11%, 19%,** and 10% of total electricity respectively in 2021, while the share of lignite dropped fourfold to 10% and that of natural gas doubled, reaching 41%.
- **The Greek energy market is compliant with the EU's Target Model and** operates via the HEnEx, which oversees four wholesale electricity markets within the Interconnected electricity system: a) the Forward Market, b) the Day-Ahead Market, c) the Intra-Day Market and d) the Balancing market.
- **To alleviate the impact of rising electricity prices in 2022, Greece introduced** significant support measures for both households and businesses, which accounted for 5.2% of previous year's GDP.
- **CO_2 emissions primarily stem from the burning of fossil fuels in the energy** sector. Concurrently, the most significant source of emissions within the energy sector is the combustion of fuels for electricity and heat generation.
- **Carbon pricing is based on the idea that "polluters must pay" and is** implemented mainly in the form of a carbon tax on the carbon content of fossil fuels or a carbon emissions trading system (ETS).
- **The recent energy crisis has significantly contributed to expediting the global** shift from fossil fuels to renewables, rendering the latter more competitive and gaining reinforcement through national initiatives like the REPower EU Plan, aimed at enhancing energy security.
- **Greece has placed a strong emphasis on prioritizing electricity generation** from RES, bolstered by domestic and EU regulations. Aligned with these, the Greek National Energy and Climate Plan established ambitious goals, such as a minimum RES share of 35% in energy consumption.
- **Cutting-edge technologies, such as carbon sequestration techniques,** designed to alleviate greenhouse gas impact by curbing carbon dioxide emissions from sources like power plants, along with harnessing hydrogen as a novel, eco-friendly fuel, are key pathways for achieving a net-zero future.

The Greek energy landscape

Overview of the Greek energy landscape





Source: Eurostat Energy – Complete energy balances, Data processing Alpha Bank

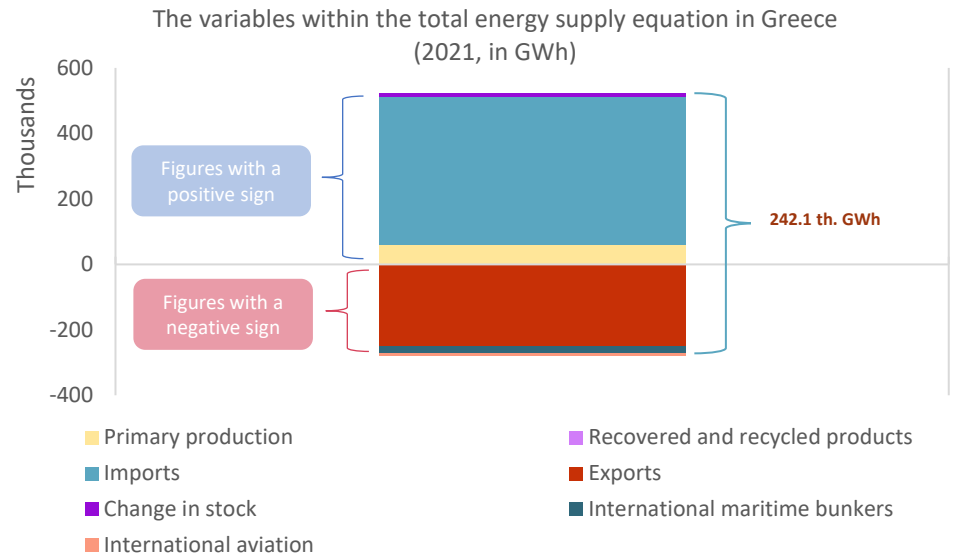
The energy system is a multifaceted entity, encompassing the composite process of converting energy products into various forms of energy.

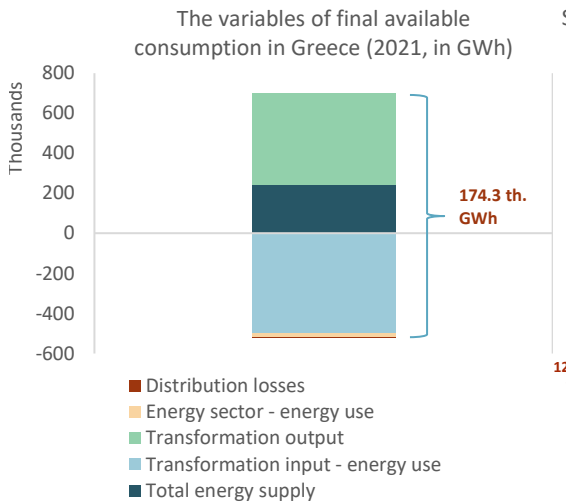
Greece's energy landscape has undergone a significant transformation over the last decade. The country's primary energy production has shifted away from solid fossil fuels towards a greater reliance on renewable energy sources. Solid fossil fuels encompass various types of coal and coal byproducts, with lignite, a low-grade coal with a carbon concentration ranging from 25% to 35%, being the country's predominant solid fossil fuel source (www.eia.gov). In 2011, lignite comprised for 78% of Greece's primary energy production, with renewables and biofuels contributing 21%. However, by 2021, the share of solid fossil fuels in primary production had decreased to 28%, while that of renewables and biofuels had surged to 71%, driven by factors such as the government's commitment to reducing greenhouse gas emissions and the growing cost competitiveness of renewable energy technologies.

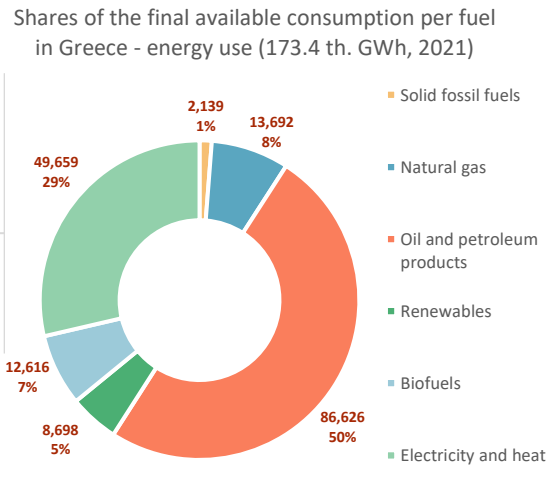
Overall, Greece's available energy from all sources comprises primary and imported energy products, with a small fraction (15%) directly powering the energy system for final consumption (direct carry-over), while the majority (85%) is utilized as input for energy transformation processes. The two principal outputs of energy transformation are electricity, the vast part of which fulfils domestic consumption, and products of oil refineries and the petrochemical industry, a large portion of which is exported, while the remainder is used for domestic energy consumption.

Energy product imports, dominated by oil and natural gas, surged from 344.2 th. GWh in 2011 to 450.8 th. GWh in 2021. Oil and petroleum products increased by 31% cumulatively from 2011 to 2021, accounting for 83% of all energy imports in 2021. Meanwhile, natural gas imports grew by 37% within the same timeframe, contributing 14% to total energy imports. Greece's energy exports encompass refined oil products (98%) and a minor portion of electricity (2%), totaling 250 th. GWh in 2021.

Energy supply and demand in Greece







Source: Eurostat Energy – Complete energy balances, Data processing Alpha Bank

The energy system is a complex network of flows from producers to consumers, such as households, businesses and transportation.

The energy system can be divided into two main components: the total energy supply and the total available energy for final consumption. The total energy supply represents all available energy to a country that comes from domestic primary production and net energy imports (exports subtracted from imports). A more comprehensive expression of this equation also encompasses secondary elements of relatively lesser importance, such as the addition of recovered and recycled products, the change in stock, and the subtraction of international maritime bunkers and international aviation. In 2021, Greece's total energy supply amounted to 242.1 th. GWh, marking a 22% reduction from 2011. Notably, net imports of energy products reached nearly 200.2 th. GWh in 2021.

Additionally, the energy allocated for domestic consumption is referred to as the total available energy for final consumption. This quantity equates to the total energy supply when we subtract energy transformation losses (transformation input minus transformation output), distribution losses, and energy use by the energy sector. In 2021, Greece's available energy for final consumption amounted to nearly 174.3 th. GWh, accounting for 72% of the total energy supply. This figure exhibited an 18% decrease compared to a decade earlier.

The available energy for final consumption can be also expressed as the sum of consumption for energy use purposes and for non-energy purposes (while excluding any statistical differences). Energy consumption for energy use dominates total final energy consumption as it accounts for over 95%. In 2021, consumption for energy use equated to 173.4 th. GWh. Within this, half was allocated to oil and petroleum products, including gas oil, diesel oil, and motor gasoline, 29% to electricity and heat, 8% to natural gas, 7% to biofuels, of which mainly primary solid biofuels (5%), alongside blended biodiesels, 5% to renewables, primarily involving heat pumps and solar thermal sources, and nearly 1% to solid fossil fuels, mainly in distinct forms of bituminous coal.

Operation of the electricity market and the power generation mix

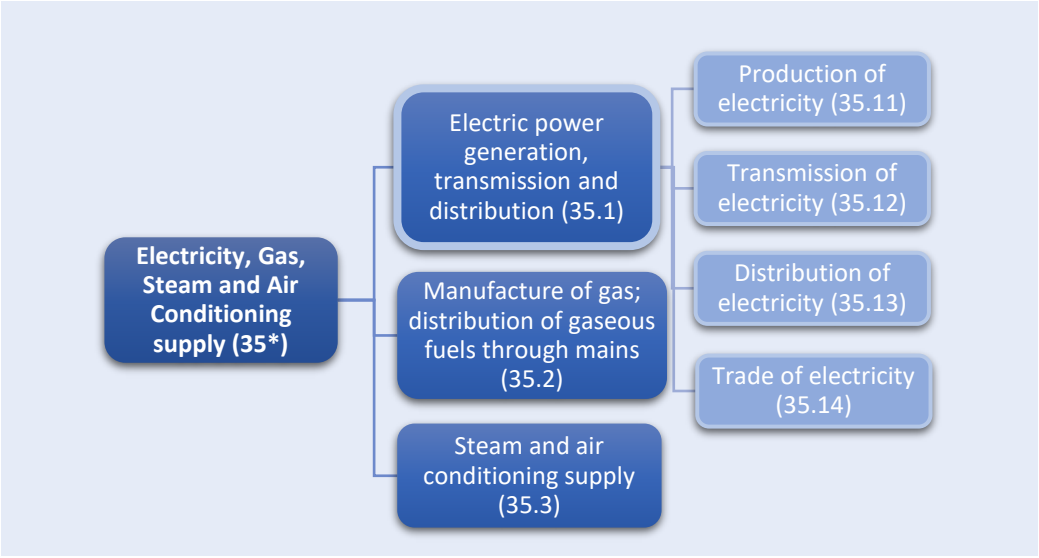
Structure of the electricity sector

The electricity sector

The electricity sector, which includes electric power generation, transmission, and distribution, is a subset of a broader sector that encompasses utilities such as gas, steam, and air-conditioning services. According to Eurostat's NACE classification, the electricity sector is further divided into distinct subdivisions: a) electricity production, b) electricity transmission, c) electricity distribution, and d) electricity trading.

These divisions encompass various activities, ranging from the generation of electric energy on a large scale from a variety of sources, the transmission of electricity from the production facilities to the distribution facilities, to the delivery and sale of electricity to end-users.

Sectoral division of the electricity sector according to the NACE Classification



* within the brackets, the NACE Rev. 2 codes
Source: NACE Revision 2 Classification, Eurostat

Electricity encompasses its production, transmission, distribution, and trade.

Production of electricity

Electricity production includes the "operation of generation facilities that produce electric energy, including thermal, nuclear, hydroelectric, gas turbine, diesel and renewable" (NACE Rev. 2). Electricity producers encompass both those who generate electricity primarily for sale to third parties (main activity producers), as well as those who generate it mainly for their own operational needs (auto producers) (Eurostat 2016).

Transmission of electricity

Electricity transmission includes the "operation of transmission systems that convey the electricity from the generation facility to the distribution system" and it aims at minimizing energy losses over long distances. It entails the transfer of very high and high voltage electricity from production sites (both conventional power plants and RES) to electricity suppliers and large industrial consumers, via the electricity grid, i.e., the interconnected electricity transmission system.

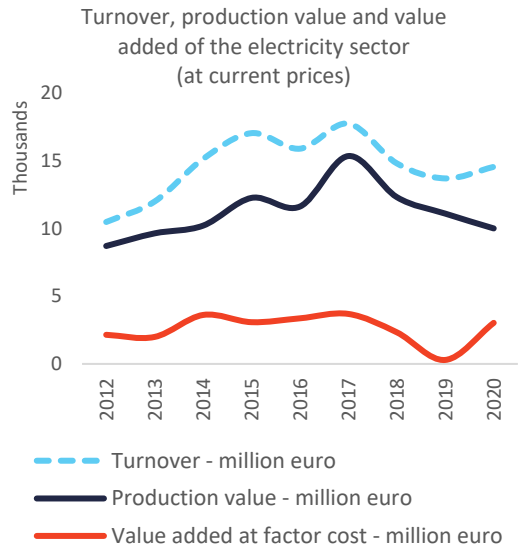
Distribution of electricity

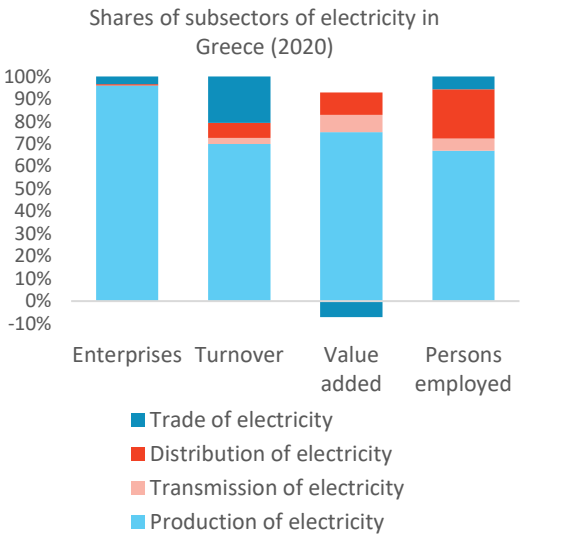
Electricity distribution is the "operation of distribution systems that convey electric power received from the generation facility or the transmission system to the final consumer". The medium and low-voltage electricity distribution network delivers power from the high-voltage grid to residential, commercial, and industrial consumers through power lines, substations, and transformers.

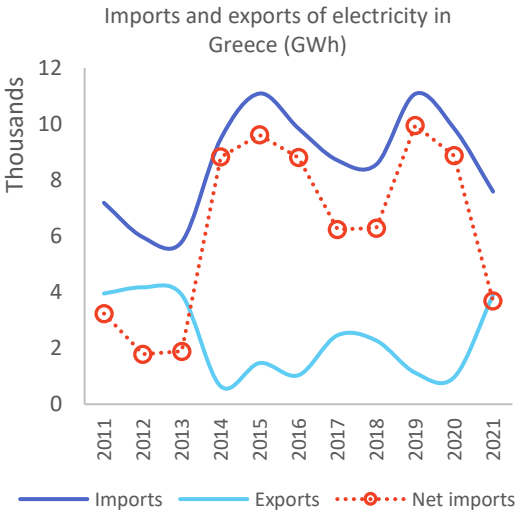
Trade of electricity

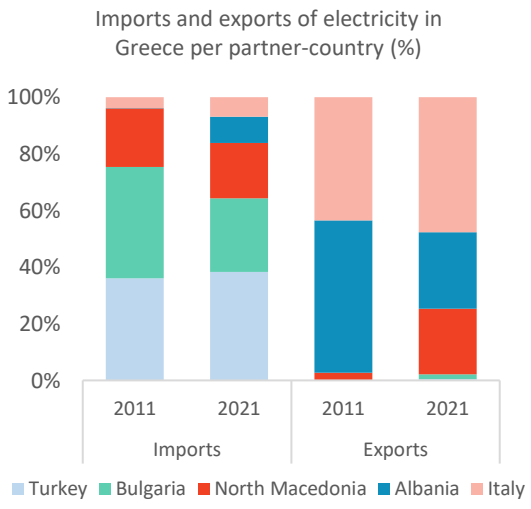
Electricity trade typically includes companies and activities related to the buying and selling of electricity, such as a) selling electricity to end-users, b) acting as intermediaries (electric power brokers or agents) to facilitate sales through third-party power distribution systems, and c) operating electricity and transmission capacity exchanges for the trading of electric power (NACE Rev. 2)

Main metrics of the Greek electricity sector









Source: Eurostat, Structural Business Statistics, Energy Statistics, Data processing Alpha Bank

Greece produces most of the electricity it consumes, but it also imports and exports some electricity, contingent on domestic demand.

Electricity sector

In 2020, the electricity industry, as reported in Eurostat's structural business statistics dataset, employed over 29,000 people in nearly 9,000 enterprises. It contributed more than €3 billion in value added (at current prices). Despite the challenges of the COVID-19 crisis and ensuing macroeconomic difficulties, its 2020 turnover exceeded €14.5 billion (at current prices), marking a 6% increase from the previous year.

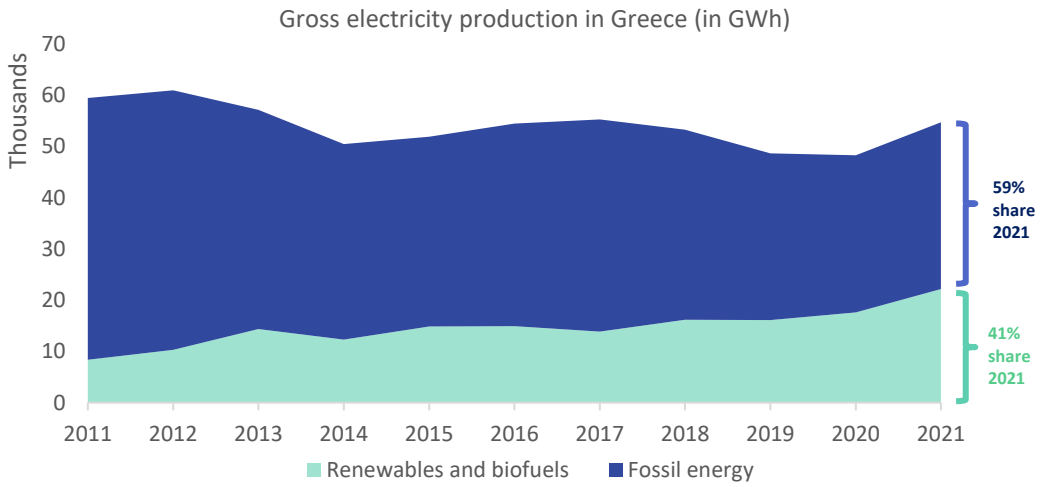
Imports and exports of electrical power

Greece participates in the EU's internal Electricity Market, allowing for electricity trade with other EU countries. Greece usually imports electricity during the summer months when demand is high and domestic production can fall short, and exports during low-demand periods, typically in winter. However, trade volumes are small compared to domestic production and consumption. In 2021, net electricity imports amounted to 3.7 th. GWh. The primary partners in Greece's electricity trade are its neighboring interconnected countries, which include Turkey, Bulgaria, Italy, Albania, and North Macedonia.

Subsectors of electricity

At a subsector level, electricity production emerges as the primary source of employment (67% of the workforce) and enterprises (96%). In terms of employment, electricity distribution secures the second position, accounting for 22% of the total workforce or equally for 6.4 thousand persons (2020). Electricity trade, despite displaying a negative value added, commands a notable presence in terms of turnover, contributing to 21% of the total turnover and 3% of the enterprises. Within the power sector, electricity transmission accounts for 9% of the GVA, 5% of the employment, and 3% of the turnover (as of 2020).

Key elements of electricity production



Source: Eurostat, Gross and net electricity production, Complete energy balances

Basic fuel categories of electricity generation in Greece

A decade ago, Greece relied heavily on fossil fuels for electricity generation. Although there has been a notable upsurge in the integration of RES in Greece's energy mix, reshaping the electricity generation landscape, fossil fuels still make up a substantial 59% of the gross electricity production (2021).

Fossil energy encompasses all types of fuels whose chemical composition is based on hydrocarbons, and it is considered a non-renewable form of energy. Fossil fuels are combustible fuel resources, i.e., they are burned to produce energy and thus contribute to the increase of CO_2 emissions. The most common forms of fossil fuels are coal, oil, and natural gas. Greece's electricity production now prominently features renewable energy sources such as solar energy, hydropower, and wind energy. Biofuels, albeit combustible fuels, because they are burnt to produce electricity, are classified as a renewable form of energy due to their origin from organic plant or animal matter.

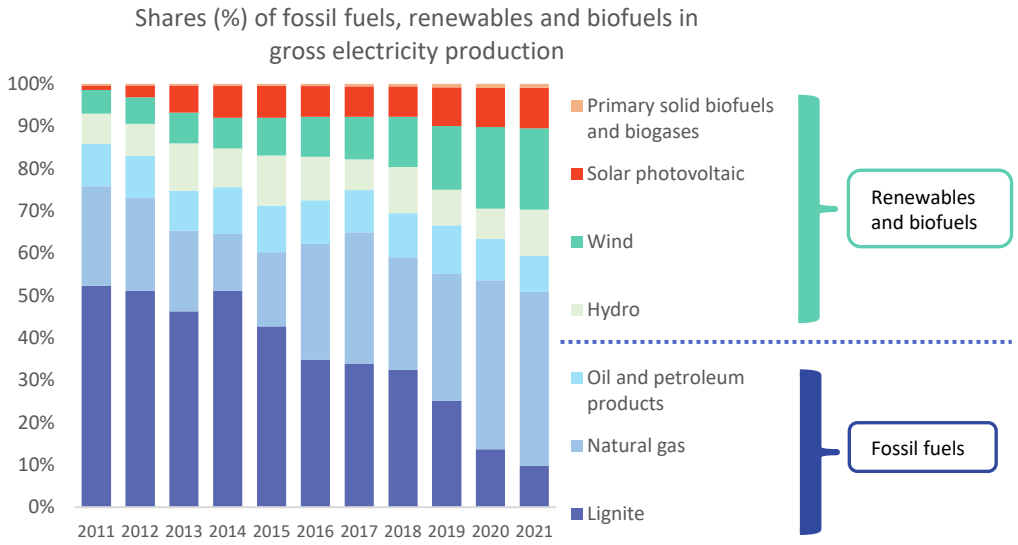
The share of fossil fuels used for electricity generation in Greece decreased by 27 pps from 2011 to 2021, yet it remains significant.

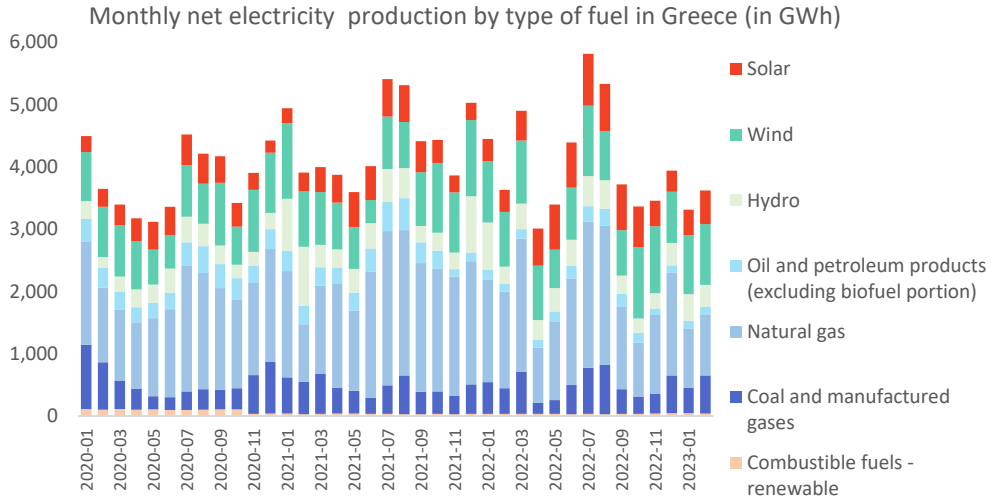
Gross and net electricity production

Electricity generation is the process of converting various energy sources into electrical energy. Within electricity generation, two crucial measures are gross and net production. Gross production refers to the total electricity output from power plants, including energy used for plant operations. Conversely, net production represents the electricity available to consumers after deducting the plant's internal energy consumption, often referred to as auxiliary consumption. An increase in net production compared to gross production implies reduced auxiliary consumption, indicating greater resource efficiency within the power sector. This efficiency improvement can be attributed to various factors, such as advancements in power plant technology, proper operation and maintenance of power plants, and an increased utilization of renewables (www.smard.de).

In 2021, Greece generated 54.7 thousand GWh of gross electricity, up by 13% compared to 2020. However, over the past decade, gross electricity production has decreased cumulatively by 8%. In addition, net electricity production reached 53 thousand GWh, accounting for 97% of gross production, up from 91% in 2011, suggesting an increase in power sector efficiency. Of the total electricity produced, 90% is generated by main activity producers in plants that produce only electricity, 5% by main activity producers in combined heat and power plants (CHP), i.e., in co-generation power stations, and 5% by auto producers in CHP units. Notably, in 2011, the share of power generation by main activity producers in CHP units was three times higher than that in 2021, demonstrating higher efficiency compared to conventional power plants by minimizing waste during the conversion of fuel into electricity. This efficiency stems from their ability to utilize the residual heat generated in electricity production for additional purposes, such as heating buildings or supplying hot water for industrial processes (www.energy.gov).

The energy fuel mix in power generation





Source: Eurostat, Gross and net electricity production, Complete energy balances

Over time, there has been a gradual transition to renewable energy sources, resulting in the replacement of lignite with cleaner fuel options.

Fossil fuel mix in the power generation

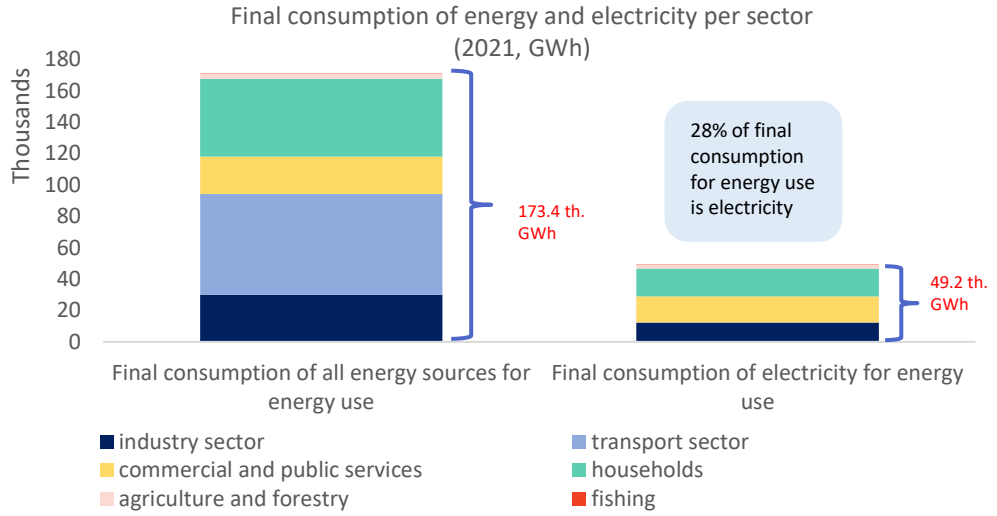
Lignite, or brown coal, is a low-grade type of coal that used to be Greece's primary fossil fuel for electricity generation. In the 1950s, Greece turned to lignite for its electricity needs due to its abundance and affordability as a domestic energy source (gr.boell.org). However, lignite is the most detrimental type of coal in terms of its impact on health and the environment. Lignite-fired power plants emit significant amounts of CO_2 into the atmosphere, and lignite mining can result in substantial environmental damage, including land degradation, water contamination, and air pollution (epa.gov).

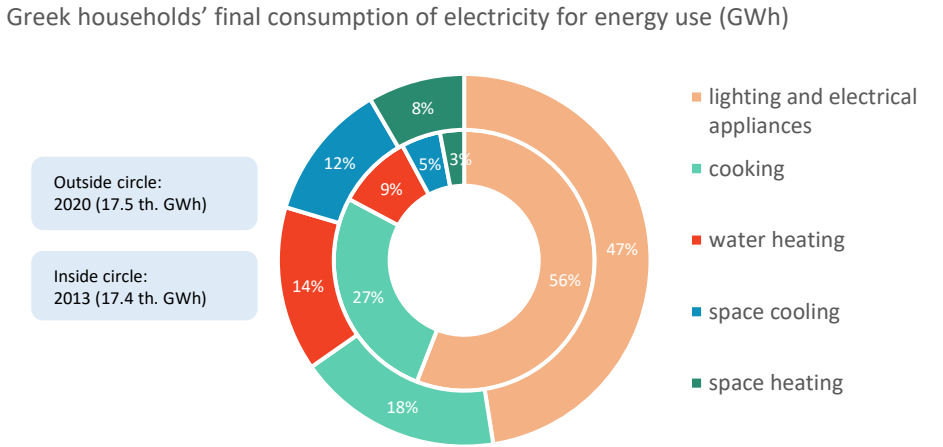
In 2011, lignite dominated the energy mix, accounting for more than half of the country's electricity generation. However, by 2021, there had been a remarkable decline, with its share dropping to 10%. Natural gas became a major player, contributing 41% to the electricity fuel mix in 2021 – nearly doubling its share since 2011. Following natural gas, oil accounted for 9% of the mix. Oil-based electricity production remained relatively stable, maintaining a share close to 1/10 of total electricity generation throughout the decade from 2011 to 2021.

Renewable sources in power generation

Notably, although fossil fuels dominate electricity production, their role has progressively diminished. In 2011, renewable energy sources (RES) accounted for only 14% of the country's electricity, with hydroelectric power representing the largest share (7%), trailed by onshore wind energy (6%) and solar photovoltaics (1%). By 2021, hydro, wind, and solar energy collectively comprised 11%, 19%, and 10% respectively, marking increased contributions to the nation's electricity output. Moreover, bioenergy in the form of biogases and primary solid biofuels appeared as an emerging player in power generation, although its electricity share remains minor (1% in 2021).

Electricity consumption by end-users





* Electricity consumption is the sum of gross electricity production, net electricity imports, minus losses (distribution and transmission), energy sector usage, transformation input energy, and statistical differences.

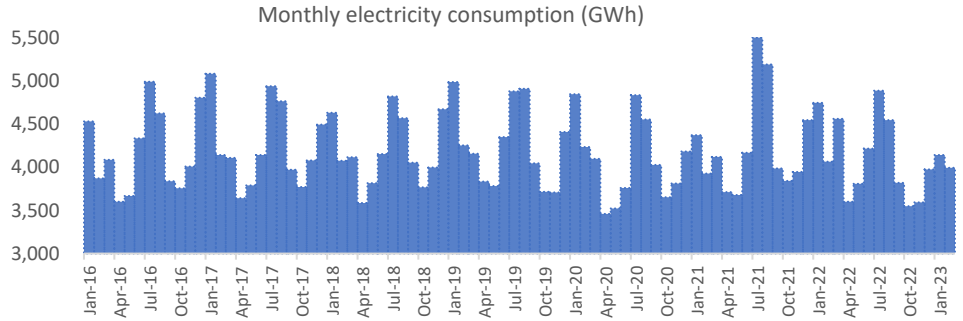
Source: Eurostat Energy – Complete energy balances, ADMIE, Data processing Alpha Bank

More than one third of total available electricity is utilized by households.

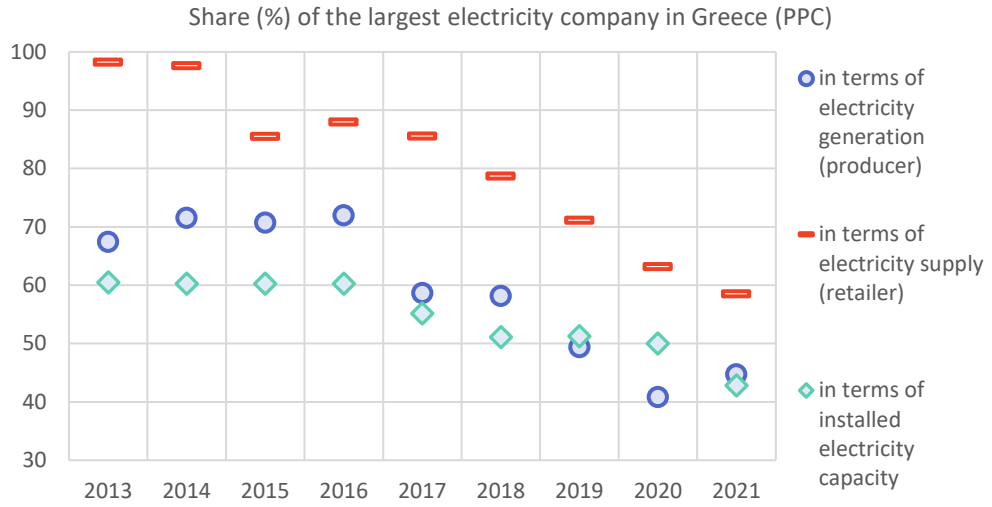
In 2021, electricity accounted for 28% (49.2 thousand GWh) of total available final energy consumption, representing nearly 90% of that year's gross electricity production. Among electricity consumers, households accounted for the largest share at 36%, trailed by commercial and public services (34%), industry (25%), and agriculture and forestry activities (5%). Within manufacturing, non-ferrous metals and food, beverages, and tobacco stood out as the most electricity-intensive sectors, contributing 8% and 4% of the total, respectively, in 2021.

In terms of household activities, 47% of the 17.5 thousand GWh of electricity consumed in 2020 was attributed to lighting and electrical appliances. Although this proportion has decreased from 56% in 2013, total household electricity consumption has remained relatively stable. Cooking emerged as the second most electricity-consuming household activity in 2020, accounting for 18% of consumption, although it experienced a significant drop from 27% in 2013. Water heating and space cooling/heating constituted for 35% of household electricity consumption in 2020, a share that has doubled since 2013.

Monthly patterns reveal that electricity demand peaks during the summer months of July and August, primarily due to the heightened utilization of air conditioning (a/c) for space cooling. This is followed by the winter months of December and January, due to increased space heating using a/c (ADMIE).



The electrical power market



Source: Electricity, Energy market indicator, Eurostat

The interconnected activities of electricity companies

In the electricity industry, there are companies that engage in activities across the subsectors of generation, transmission, distribution, and electricity trade. For instance, a supplier or retailer, who buys electricity from producers and then sell it to consumers, may also be involved in electricity generation. Companies like PPC, ELPEDISON, and HERON serve as both generators and suppliers.

Companies from diverse sectors may engage in electricity generation or direct sales to end-users, focusing on customer-centric aspects such as marketing, customer service, and billing. For instance, ELPEDISON, a subsidiary of the HELLENiQ ENERGY (formerly Hellenic Petroleum-HELPE), engages in both electricity generation and supply. Another example is the MYTILINEOS Group, operating in metallurgy, engineering, and construction. Despite its diverse interests, the group has subsidiaries like Korinthos Power engaged in electricity generation and others like Protergia functioning as electricity suppliers.

Although with reduced shares which signal increased competition, PPC maintains a strong presence in the Greek electricity market.

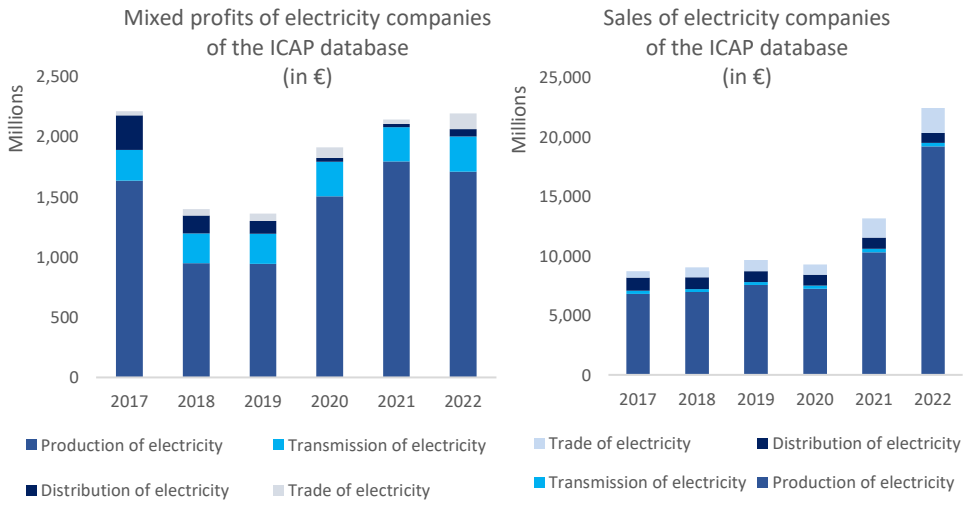
Leading actors in the electricity market

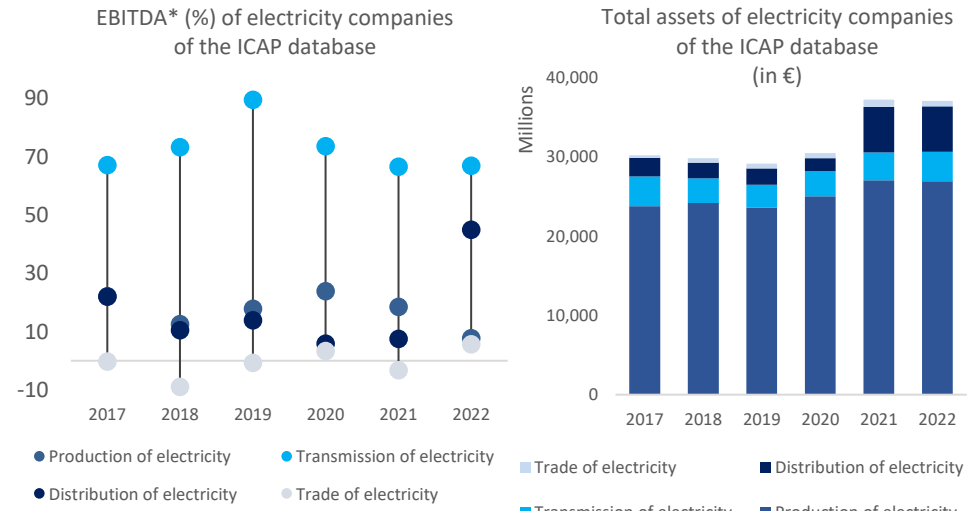
PPC, or Public Power Corporation, the largest electricity producer and supplier in Greece, boasts the highest installed capacity of 11.1 GW among power station facilities, which include lignite-fired power plants, hydroelectric facilities, and other RES. Formerly under full state ownership, PPC is now partially owned by the Greek State, with a 34.12% minority share held through the Hellenic Corporation of Assets and Participations (HCAP) sovereign wealth fund (dei.gr).

While PPC maintains a strong presence in the Greek electricity market, reduced shares signal increased competition and decreased market concentration. In 2021, PPC's share of installed capacity for conventional and RES generation stood at 43%, down from 60% in 2016. Regarding electricity generation delivered to the grid, PPC represented 45% in 2021, while other companies that hold at least 5% accounted for 18% collectively. In net production from fossil fuels and large-scale hydro units, PPC's share reaches 62%. Notable conventional and RES electricity generators also encompass ELPEDISON, boasting 840 MW of installed capacity, subsidiaries of the MYTILINEOS Group, such as Korinthos Power (437 MW of installed capacity), and HERON (582 MW of installed capacity), a subsidiary of the TERNA Group (admie.gr).

Among electricity suppliers, PPC held a 59% share of the electricity consumed by end-users in 2021, marking a substantial decrease from 88% in 2016 and 98% in 2013. Despite its reduced consumption share, PPC accounts for 73% of the number of medium and low voltage electricity meters (rae.gr). Greece's electricity retailers include companies such as ELPEDISON, Protergia, HERON, Zenith, NRG, Watt & Volt, and Fysiko Aerio, but also Volton, KEN, Volterra, ELINOIL, OTE Estate, and ELTA (admie.gr). In electricity transmission and distribution, ADMIE and DEDDIE are essentially operating as natural monopolies.

Financial performance of the electricity market





* Earnings Before Interest, Taxes and Depreciation and Amortization over revenues

Source: ICAP Dataprisma database

The spike in revenues of electricity companies in 2022 is largely driven by the elevated fuel costs due to the energy crisis.

ICAP's financial database, Dataprisma, provides a detailed overview of utilities across the electricity industry subsectors. Based on the latest data from a representative sample of large, medium, and small companies, revenues across the four subsectors recorded a substantial 70% increase in 2022 compared to 2021. In contrast, mixed profits (revenues minus variable costs) experienced a modest uptick of 2%. The total assets of the electricity sector remained constant at €37 billion, maintaining the same level as that in 2021.

In electricity generation, producers experienced a significant boost in revenues, with an 86% increase in 2022 and a 43% increase in 2021, rebounding from a 4% fall in 2020 due to the coronavirus crisis. However, these spikes are largely attributed to the energy crisis resulting from the Ukraine-Russia war, leading to elevated input costs for electricity generation fuels. Electricity producers contribute over 80% to total revenues, nearly 78% to mixed profits, and 73% to total assets as of 2022. The overall EBITDA margin, a metric indicating the profitability of electricity production companies' operations, stood at 7.7% in 2022, down from 18.4% in 2021.

Companies in the electricity trade subsector represent 9% of total sales, contributing 6% to mixed profits and accounting for 2% of total assets. Their EBITDA margin stood at 5.6% in 2022. Additionally, the electricity transmission and distribution companies of ADMIE and DEDDIE, which operate as natural monopolies, make up 1% and 4%, respectively, of the total turnover of electricity companies in 2022. Furthermore, they constitute 13% and 3%, respectively, of mixed profits. In 2022, the EBITDA margin for ADMIE and DEDDIE stood at 66.9% and 44.9%, respectively. This substantial profit margin is a consequence of their monopolistic nature, providing them with higher market power, reduced competitive pressure, and better pricing control as sole players in their respective domains.

The interconnected power transmission grid and smart distribution grids

The Greek interconnected system of electricity

The interconnected electricity system, commonly referred to as the power grid, facilitates the connection between electricity production units, conventional and renewable, and residential and non-residential electricity consumers. Electricity is distributed to consumers through the Hellenic Electricity Distribution Network, which links to the power grid at substations, at which electricity is transformed from very high and high voltage -ideal for efficient long-distance transmission- to medium and low voltage, ensuring safer usage for consumers.

The Greek power grid, operated by ADMIE/IPTO, the Public Power Corporation's Transmission System Operator, consists of over 13,000 km of transmission lines, enabling the transfer of electricity throughout mainland Greece, and connecting various islands such as those in Western Greece (Crete, Skiathos, and the Cyclades islands of Naxos, Andros, Syros, Tinos, Paros, and Mykonos). The grid comprises a combination of overhead lines, underground lines, and subsea cables, all operating at very high and high voltage levels (66kV, 150 kV, 400kV) and substations. The core of the system involves three 400kV lines, responsible for the transmission of electricity, primarily from the major production center located in Western Macedonia to the central and southern regions of Greece.

Scheduled projects for the power grid expansion

An expansion project is currently underway to enhance the Greek interconnected electricity system. The project includes several phases, such as a) connecting Crete with Attiki, b) the final stage of linking non-interconnected islands (NII) of Cyclades, such as those of Santorini, Folegandros, Milos, Serifos, and c) the eastern line of Peloponnese (Megalopoli-Corinthos-Attiki), expected to be completed by 2025. Additionally, ADMIE is planning to connect the system with the North Aegean NII islands of Limnos, Skiros and Samos, and the Dodekanese islands by 2032 (IEA 2023, ADMIE 2022, energypedia). All expansion initiatives aim to improve energy connectivity, increase reliability, and accommodate the growing energy needs in different regions of Greece.

The interconnected electricity grid is an important part of Greece's energy infrastructure, playing a key role in the country's clean energy transition.

International connections of the Greek power grid

Since 2004, the Greek interconnected system has been operating in parallel with the European Network of Transmission System Operators for Electricity (ENTSO-E) through multiple connections with neighboring countries such as Albania, Bulgaria, North Macedonia, Turkey and Italy. Recent expansion with Bulgaria is complete, and a 2GW interconnector is expected to be operational by 2028. Plans and proposals also include a) a 3GW interconnection between Egypt and Europe via Greece (EuroAfrica project), b) linking Cyprus and Israel's grids to Europe through Greece, c) smaller interconnections with Balkan neighbors like Albania and Romania, and d) a Greece-Austria-Germany (GAG) interconnector of up to 9 GW of electricity from Greek renewable power capacity, set to be operational by 2030 (ADMIE 2023, RAE 2021, IEA 2023, renewablesnow.com).

Smart grids and digitalization of the distribution network

DEDDIE, the Greek electricity distribution company, is prioritizing the modernization of the electricity distribution network and its transformation to a smart grid. Smart grids use digital technologies to monitor and manage the electricity distribution network. This allows for better network control and can help to reduce outages and improve energy efficiency. The distribution network digitalization is a key priority of the National Energy and Climate Plan.

By 2030, digital smart meters will replace conventional ones for all low-voltage consumers and provide real-time data on electricity consumption, used by consumers to better manage their energy use, and by DEDDIE to better manage the network. The network's digitalization via smart grids is supported by the European Investment Bank and Recovery and Resilience Facility loans (DEDDIE, IEA 2023, Greece 2.0 2021). By digitizing the network, Greece can improve its efficiency and reliability, and support the growth of renewable energy.

ALPHA BANK

Electricity regulatory framework and funding of RES projects

The regulatory regime of electricity and RES in the EU

The EU's electricity regulatory framework

The European Union has been gradually reforming its electricity market over the past decade. In 2009, the EU introduced the "Third Energy Package" to regulate the internal energy market and cross-border electricity exchanges. This package also established the Agency for the Cooperation of Energy Regulators (ACER) to coordinate actions among national energy regulators. Furthermore, to ensure the integrity and transparency of the electricity market, the EU adopted the Regulation on wholesale energy market integrity and transparency, which further strengthened the rules on market integrity and fair competition (EC 2023).

In 2019, the EU adopted the "Clean energy for all Europeans package", which included new rules for the internal market for electricity, aiming to facilitate the free movement of electricity, encourage investments in energy supply security and decarbonization through the increased use of RES, strengthen competition and allow cross-border electricity trade (EC 2019). In 2023, the EU proposed a further revision of the electricity market rules in response to the 2022 energy crisis, aiming to strengthen the market and make it more resilient to future shocks. The proposed reforms aim to improve consumer protection, strengthen the rules against market manipulation, and expand the use of renewable energy, by requiring member states to increase the share of RES in their electricity mix, and providing financial support for renewable energy projects.

Consumer protection and market integrity

One of the main goals of the proposed reforms of the new electricity market design is to improve consumer protection. The reforms would give consumers the right to fixed-price contracts, more choices in the electricity market, and stronger protection against market manipulation, while enhancing ACER's authority for investigating and penalizing market manipulation. They would also require stronger national authority protection against manipulation, along with safeguarding vulnerable consumers from disconnection and regulated retail prices during a crisis (EC 2023).

The EU's electricity market is more resilient to disruptions than a fragmented market and helps to ensure a steady supply of electricity.

The EU's Renewable Energy Directive (RED) and the Fit for 55 Package

The European Union has set ambitious targets for the use of renewable energy and has specified a framework for the promotion of RES in the EU. In 2009, the EU adopted a directive (2009/28/EC) that set a target of 20% for the share of renewable energy in gross final consumption by 2020. In the context of the "Clean energy for all Europeans package" the Renewable Energy Directive (RED) was revised in 2018, and the new target was set at 32% for 2030 (EU 2018/2001). The revised directive included rules on financial support for renewable energy projects, self-consumption of renewable energy, and the use of RES in the transport, heating, and cooling sectors.

In 2021, the EU proposed the revision of the renewables' directive again, in the context of the "Fit for 55" package, a set of legislative proposals designed and adopted by the European Commission to help the EU achieve its climate neutrality target by 2050. The new directive set a new target for the share of renewable energy in gross final consumption for 2030 at 40% and included new rules on the use of RES in transportation.

REPowerEU plan

REPowerEU is a new plan presented by the European Commission in 2022 to reduce the EU's reliance on fossil fuels and its dependence on Russian gas and oil, and to accelerate the energy transition. The plan includes a number of measures, such as a) a higher target for the share of RES in the electricity mix, from 40% to 45% by 2030, b) a faster permission process for solar and wind energy projects, c) increased energy savings by raising the target for energy efficiency to 13% from 9% by 2030, d) higher energy efficiency in the transport sector, e) boosting the decarbonization of the industrial sector and e) investing in gas and electricity infrastructure networks (EC 2018, 2022, 2023 and EP 2021).

The electricity and RES regulatory framework in Greece

A brief history of electricity production in Greece

Electricity production in Greece started in 1889 with a private company in central Athens. In the early 20th century, international firms like American Thomson-Houston generated electricity in major cities. Meanwhile, smaller cities were served by approximately 400 small private and municipal firms, all using oil and coal for power generation. Lignite was first used in Aliveri in 1871 and later in Ptolemais, by Greek refugees from Asia Minor after 1922. In 1950, the Public Power Corporation (PPC) was founded, developing lignite and hydroelectric power units. By 1956, PPC had acquired all small private and municipal electricity companies, establishing a monopoly in electricity production and trade until the Greek electricity market was liberalized (ICAP 2022).

The Greek RES regulatory framework and feed-in support mechanisms

The first regulatory framework for RES in Greece was introduced in 1985, allowing PPC and municipal companies to operate in this domain. In 1994, private companies were also allowed to produce electricity from RES, and their production was exclusively supplied to and bought by PPC at stable prices. In 2006, the permission process for electricity production units using RES was revised and national targets for RES share in electricity consumption were established. In 2012, a law on the rationalization of the RES market was adopted.

In Greece, RES production is incentivized through two main mechanisms. The first is the feed-in tariff (FIT), which offers a fixed payment to RES generators for their electricity production. Additionally, a feed-in premium (FIP) system was introduced in 2016, providing a variable payment based on the difference between the market price of electricity and a fixed rate known as the “special market price” (SMP). The Greek government has chosen the FIP as the primary support mechanism for RES projects on the mainland grid and interconnected islands, regardless of size (ICAP 2018, Stochasis 2022). In 2020 and 2022, revisions were made to the RES power unit permission process and a new goal was set for a 60% RES share in total electricity consumption (energypedia).

The liberalization of the Greek electricity market boosted competition and gave consumers more electricity supply options to choose from.

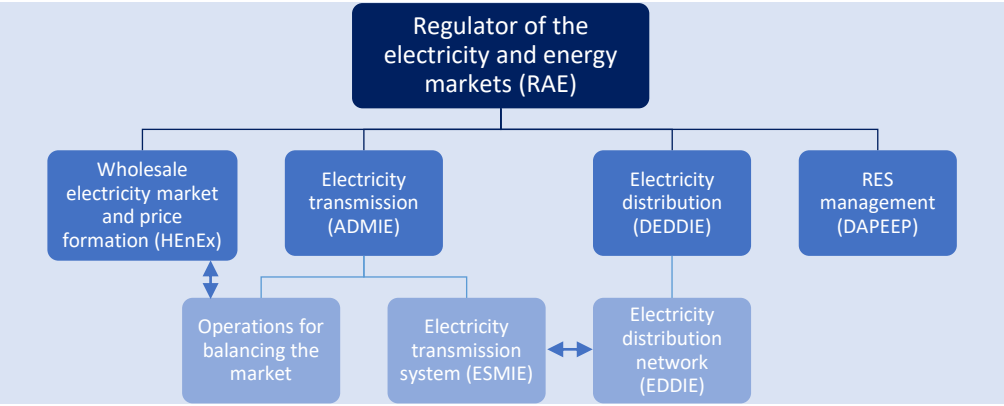
Liberalization of the Greek electricity market

In 1998, the EU adopted the Electricity Directive, mandating member states to liberalize their electricity markets. Greece began this process in 2001 through L.2773/1999, in compliance with the EU imperative, allowing other companies to enter the market. The law also established the Regulatory Authority for Energy (RAE) and the Hellenic Transmission System Operator and regulated the transformation of PPC into a Société Anonyme. In 2011, ADMIE and DEDDIE were created, separating transmission and distribution from PPC, and establishing the Hellenic Electricity Market Operator (LAGIE).

In 2014, the EC approved the Greek government’s plan for further liberalization of the electricity market, which included measures such as the break-up of the state-owned monopoly to allow for the entry of private enterprises in the market. In the beginning of 2014, the Greek government announced the selling of a 35% stake in PPC and auctioned off 10 new licenses for electricity generation, igniting a surge of interest from numerous new companies, all keen on capitalizing on these emerging prospects (ICAP 2018, IOBE 2021, Stochasis 2022).

The liberalization of the electricity market in Greece resulted in several positive outcomes as it led to a gradual increase in the number of suppliers and a decrease in electricity prices. The entry of private electricity production and trade firms into the market fostered healthier and fair competition, offering consumers a broader array of flexible services and options for their electricity supply, such as green energy options and time-of-use (TOU) tariffs that charge different rates for electricity depending on the time of day. Non-household consumers have been able to choose their electricity provider since July 2004, whereas household consumers were given the right to choose since 2007, with the exception of the non-connected islands.

Main institutional entities and operators of the power system



Regulatory Authority for Energy (RAE)

RAE, now known as RAAEY (Regulatory Authority for Waste, Energy and Water), operates as an independent regulatory authority responsible, among others, for monitoring and regulating the energy and electricity markets. It also supervises both the wholesale and retail energy markets, ensuring fair competition and stable prices for consumers. RAE's primary objectives encompass the liberalization of the energy market through the proposal and enforcement of regulations. Additionally, it aligns its efforts with the energy policy's core targets, which include ensuring a reliable energy supply to consumers, promoting supply security, and protecting the environment (www.rae.gr).

Hellenic Energy Exchange Market (HEnEx-EXE)

The Hellenic Energy Exchange Market (HEnEx-EXE) commenced its operations in November 2020 and earned the designation by RAE as the Nominated Electricity Market Operator (NEMO) for the Greek Bidding Zone. HEnEx operates the Energy Trading Spot System (ETSS) and the Natural Gas Trading Platform powered by ATHEXGroup. It is also responsible for the operation of three out of four markets of the wholesale electricity market: the Forward Market, the Day-ahead Market, and the Intra-day Market (www.henex.gr).

The Greek power system encompasses various participants, with RAE regulating and monitoring the energy and electricity markets.

Independent Power Transmission Operator (IPTO-ADMIE)

Electricity transmission is managed by the Independent Power Transmission Operator, which manages the interconnected Hellenic Electricity Transmission System (HETS-ESMIE). Established in 1995 as a state-owned enterprise, IPTO was privatized in 2017, with ADMIE as its parent company, mainly owned by the Greek government. ADMIE's key responsibilities include operating, controlling, maintaining, and expanding the ESMIE. It plays a crucial role in facilitating cross-border electricity trade and operates the Balancing Market, a part of the wholesale electricity market, with its primary focus on ensuring reliable and efficient electricity transmission (www.admie.gr).

Hellenic Electricity Distribution Network Operator (HEDNO-DEDDIE)

DEDDIE, a subsidiary of PPC, operates and maintains the Hellenic Electricity Distribution Network (HEDN-EDDIE) development of the HEDN, which includes medium and low voltage systems. DEDDIE also manages the markets of the non-connected islands. DEDDIE's primary focus is to ensure equal access to the HEDN for consumers, providers, and suppliers, promoting fairness and efficiency in electricity distribution (www.deddie.gr).

Operator of RES and Guarantees of Origin (DAPEEP)

DAPEEP was founded in 2009 as the successor of the Hellenic Electricity Market Operator (LAGIE). DAPEEP is a non-profit organization and plays an important role in the Greek renewable energy sector. It is responsible for managing the Greek Guarantees of Origin (GO) system that ensures that RES producers are fairly compensated for their electricity, for auctioning emission rights, and for administering the Special Account for RES and CHP, which supports the development of renewable energy projects (www.dapeep.gr).

“Power up” in the NRRP and NSFR interconnection projects

“Power up” in the National Recovery and Resilience Plan

The Greece 2.0 National Recovery and Resilience Plan, formulated in 2021, places significant emphasis on energy investment. Under its Green Transition Pillar, the plan allocates a total of €6.194 bn from the EU’s RRF for this purpose, with an estimated mobilized investment of €11.604 bn. A substantial portion of this funding, specifically €1.200 bn (8% of all RRF grants), is dedicated to "Power up," a component which focuses on energy-related projects. The primary investment areas of Power up are the transmission and distribution of electricity interconnections, the promotion of RES, the enhancement of energy supply security, and the tackling of climate change challenges. A total investment of €2.348 bn is expected to be mobilized under the Power up related projects.

The Power up objectives align with the EU Green Deal strategy and encompass key goals such as the green transition and greenhouse gas reduction, the RES increase in energy consumption, energy security and the mitigation of the vulnerabilities of interconnection infrastructures. The proposed reforms to help achieve these goals are: 1) restructuring and strengthening the RES CHP Account (known as ELAPE) and 2) streamlining the efficient operation of the new electricity market model and accelerating the licensing procedure for new RES plants to meet the NECP targets (€200 million).

The six investments linked to the Power up objectives are: a) establishment of electric energy storage systems critical for RES development (€450 million), b) restoration of old lignite mine territories in western Macedonia and Megalopolis (€242 million), c) initiatives to enhance electricity interconnection among islands and upgrade the electricity network (€195 million), d) undergrounding and modernizing of the electricity distribution network (DEDDIE) in urban areas to safeguard against extreme weather events (€60 million), e) upgrading the electricity distribution network in forest areas to prevent fire (€40 million) and f) increasing the power capacity of HV/MV substations to facilitate the integration of new RES.

Power up, as an EU Recovery and Resilience Facility flagship, shares aligned objectives with the EU Green Deal Strategy.

Expected contribution to promoting the European Flagship Initiatives

Power up serves as an EU flagship of the RRF plan driving investments and reforms to accelerate recovery while prioritizing "Future-proof clean technologies" and expediting the development, integration, and utilization of renewable energy sources through modernized networks and enhanced interconnectivity. This strategic approach lays the foundation for establishing the EU's leading hydrogen markets (EC 2020).

In line with these objectives, the Greek Power up component of the RRF will contribute to the promotion of EU flagship initiatives through a) developing and integrating new RES capacity of at least 3 GW, b) installing 1.38 GW of energy storage capacity, c) increasing the installed capacity by 800 MVA in existing HV/MV substations of the electricity distribution network, facilitating the integration of 1.755 MW of RES capacity into the network, d) developing 150 kV cables (353 km of submarine cables and 20 km of land cables) for the Cyclades interconnection, projected to reduce CO_2 emissions by 99,562 tonnes/year from 2025 and by 120,808 tonnes/year in 2030 (Greece 2.0 2021).

NSRF electricity-related projects

The 2014-2020 National Strategic Reference Framework (NSRF) focused on improving the electricity distribution network and infrastructure, with two standout projects set for completion by the end of 2023: the Crete-Attica electricity interconnection project (€995 million), ranked among Europe's top 5 most innovative DC interconnection projects, and the electrical interconnection of Crete with Peloponnese (€356 million). The NSRF of the 2021-2027 programming period continues to fund projects in line with the RRF, including interventions for the undergrounding of aerial electricity transmission and the upgrading of the urban and forest areas distribution network.

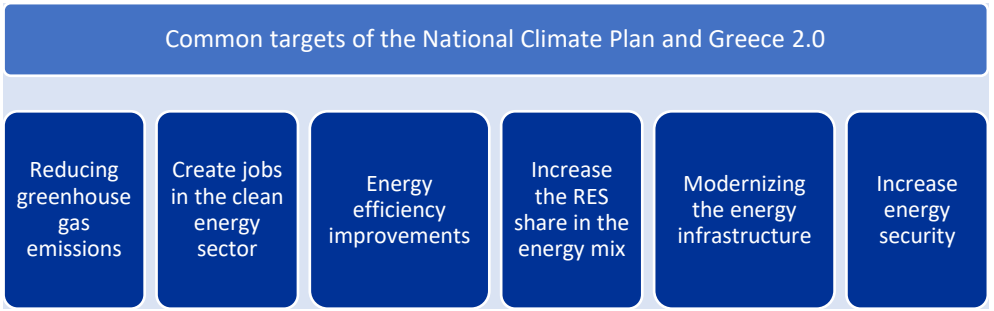
National energy and climate strategy and the Territorial Just Transition Plan

The Greek National Energy and Climate Plan (NECP)

The Greek NECP is a 10-year plan that sets out the country's energy and climate goals for 2030. It was adopted in December 2019 and serves as the country's national energy policy in line with the Paris Agreement's targets to limit the global temperature rise to 1.5ºC and achieve net-zero emissions by 2050. NECP centers around energy transition and sets forth more stringent climate and energy targets for 2030 than the EU targets.

The key objectives of the Greek NECP are 1) reducing greenhouse gas emissions by over 42% until 2030 compared to 1990 levels, by implementing emission-cutting measures in transport, agriculture, and manufacturing, 2) attaining a minimum 35% share of RES in gross final energy consumption (EU: 32%), with targets of 40% in heating and cooling and 19% in transport, 3) improving energy efficiency in final energy consumption by 38% (EU: 32.5%) through initiatives to lower it compared to 2017 levels (NECP 2019). The NECP also aspires to create around 100,000 jobs in the clean energy sector by 2030.

The Green transition pillar of the Greek NRRP/Greece 2.0 is aligned with many of the strategic priorities of the NECP; thus, both have a number of common targets, such as the substantial reduction of carbon dioxide emissions by 2030, the RES deployment in the energy mix, and the increasing energy efficiency and energy security of the country (NECP 2019, Greece 2.0 2021).



The Greek NECP strives to meet targets that will bring substantial progress towards a sustainable energy future for Greece.

The National and Territorial Just Transition Plan

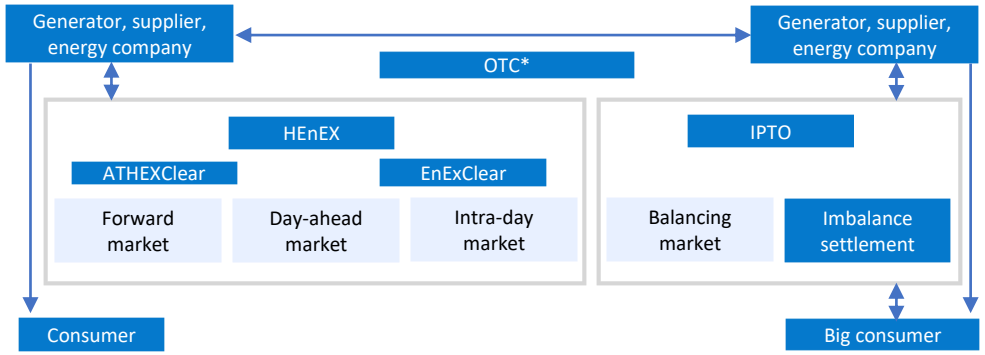
The National and Territorial Just Transition Plan (NTJTP) is linked to the EU Just Transition Mechanism, an integral part of the EU Green Deal, which incorporates the Just Transition Fund (JTF) with a total investment of €17.5 billion scheduled for the period 2021-2027. The primary focus of the NTJTP is to address the economic and social challenges arising in Western Macedonia and Megalopolis due to the complete phase-out of lignite-fired power stations. Greece is estimated to benefit from grants of €1.38 billion from the JTF to facilitate a just and sustainable socio-economic transition in these regions and the affected communities. The Plan includes measures such as a) creating jobs in the clean energy sector, b) investing in RES projects, c) developing new skills and training programs and d) supporting businesses in their clean energy transition (EC 2021, 2022; Just Transition Development Plan of lignite areas 2020).

Electricity sector under the NECP

The Greek NECP sets a target for a minimum 65% share of RES in electricity production and 60% in electricity consumption by 2030. To achieve this ambitious target, the NECP includes measures, such as simplifying and accelerating the permission process for RES power plants, integrating RES in the power system, operating energy storage systems, and promoting electromobility. In addition to the target for RES, the NECP also includes a goal to end lignite use in electricity production and close all lignite-fired power plants by 2028. Ending lignite use would be a major step forward for Greece in its efforts to address climate change. However, in order to face the energy crisis, the Greek government has decided to extend the operation of seven lignite-fired power plants until the end of 2025, casting doubts on Greece's commitment to climate action (NECP 2019, Greece 2.0 2021, www.kathimerini.gr).

Electricity price formation

Market integration, price formation and the target model



*OTC stands for Over-the-Counter transactions, i.e., off-market transactions of electricity contracts
Source: Makrygiorgou et al. 2023. *The electricity market in Greece: Current status, identified challenges and arranged reforms*. Sustainability

Integration of markets and the EU's electricity market Target Model

The EU's Target Model for electricity markets is an ambitious initiative currently in progress. Its goal is to establish an integrated, efficient, competitive, and sustainable electricity market within the EU, under unified regulations and rules. The concept was introduced in 2011 and has been progressively put into action. These regulations originated within the Third Energy Package and were subsequently expanded as part of the Clean Energy for All Europeans package in 2019 (Regulation EU no. 1227/2011, rae.gr).

The Target Model is based on the following principles: a) *unbundling of* electricity generation, transmission, and distribution companies so that they are legally separated from each other, b) *cross-border cooperation* of the national transmission system operators for fair and competitive prices across the EU, c) *market transparency*, so that market participants have access to the same information about prices, supply, and demand, and d) *integration of RES* into the electricity grid, by facilitating participation and by offering incentives. Other features of the Target model include market coupling, capacity mechanisms and consumer empowerment in energy transition (energy.ec.europa).

The Greek electricity market is a complex system designed to ensure that electricity is supplied to consumers at a fair price.

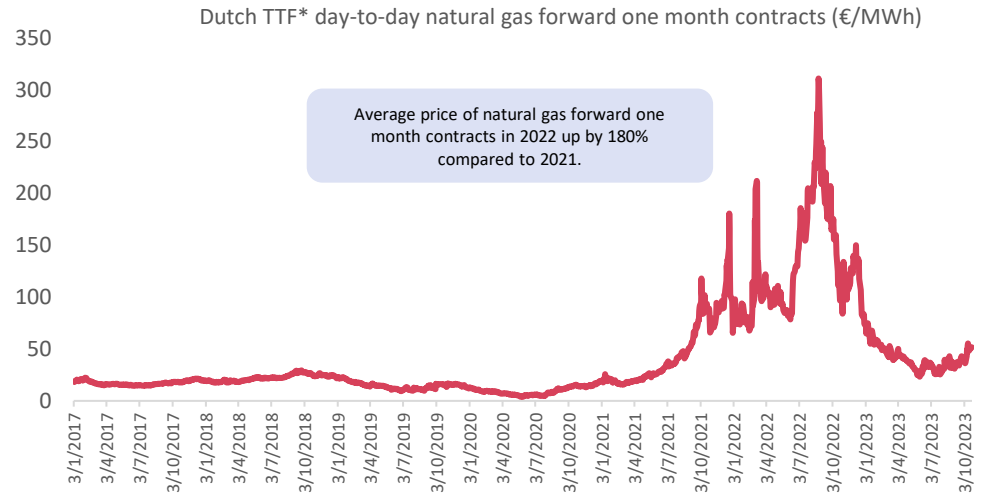
Wholesale electricity markets and the pay-as-clear mechanism

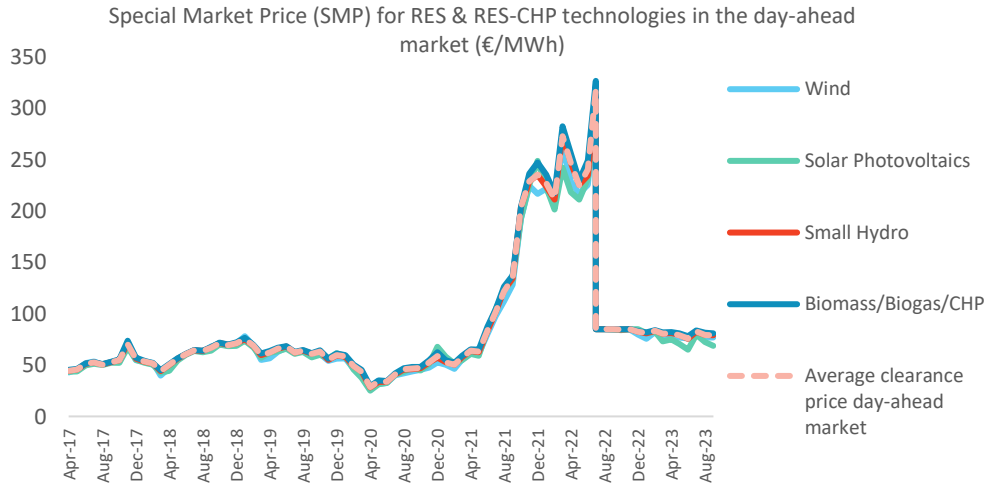
The Greek energy market is compliant with the EU's Target Model and operates through the HEnEx. This platform oversees four separate wholesale electricity markets within the interconnected electricity system: a) the *Forward Market*, b) the *Day-Ahead Market*, c) the *Intra-Day Market* and d) the *Balancing market* (admie.gr). In this setup, generators and suppliers engage in transactions to sell their electricity production, meeting consumer demand. HEnEx's objective is to facilitate efficient price determination through wholesale market operations. ADMIE manages these markets and balances the system, i.e., corrects any imbalances between supply and demand in real time (EnExGroup).

The Forward Market allows market participants to trade electricity for future delivery, ranging from weeks to years, to hedge against price fluctuations (Makrygiorgou et al 2023). The Day-Ahead Market is for transactions that will take place on the following day and holds significant importance. Prices are determined through an auction process, known as *price-as-clear* auction, where generators submit bids specifying the electricity quantity they are willing to generate and the price they are willing to accept. These bids are ranked in ascending order, with contracts awarded to the lowest-cost bids. The wholesale price is determined by the cost of the last accepted bid, representing the last power plant required to meet demand and ensuring that all generators receive the same price for the electricity they sell at any given moment (eurelectric.org).

The Intra-Day Market is for transactions that can take place on the same day as the delivery date, with prices determined through a continuous trading process (*pay-as-bid* procedure). The Balancing Market balances supply and demand in real time. It ensures that the grid remains in equilibrium despite fluctuations in consumption and generation.

Key factors affecting electricity prices and the wholesale merit order process





* The Dutch Title Transfer Facility (TTF) is the largest and most liquid gas trading hub in Europe, and is used as a benchmark for gas prices across the continent.

Source: Bloomberg, DAPEEP

The cost of fuels is the most significant factor affecting electricity prices, so the energy sources used to generate electricity significantly shape prices.

Key factors affecting electricity prices

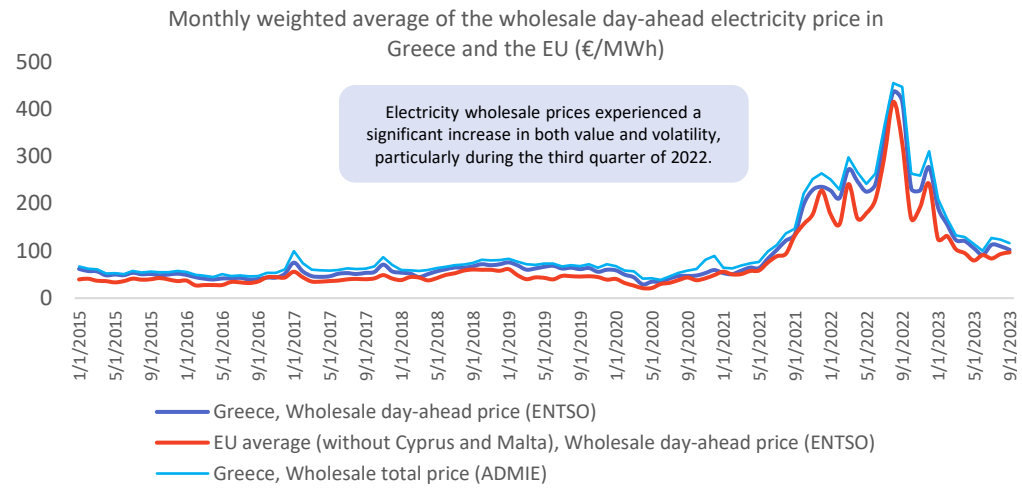
Electricity prices are directly linked to the cost of fuels, such as natural gas, oil and coal, making the choice of energy sources a key factor in shaping these prices. Yet, aside from fuel expenses, various other factors affect electricity prices. These include electricity supply and demand, the availability of RES, power plant expenses, transmission and distribution costs, competitive market dynamics, structural features of the market, weather conditions, seasonal fluctuations, geopolitical events, natural disasters, regulations and policies, technological advancements, and financial market speculation.

In the wake of the Russian-Ukraine conflict and the subsequent energy crisis, natural gas, constituting 40% of the Greek electricity generation mix, witnessed a substantial price upsurge. In 2022, the average one-month forward contract price for natural gas at the Title Transfer Facility (TTF) Virtual Trading Point surged to 132.66 €/MWh, up from 47.38 €/MWh in 2021, before declining in 2023. Simultaneously, the Special Market Price (SMP) for RES and RES-CHP technologies in the Greek day-ahead market initially surged by 48%, only to subsequently fall substantially in mid-2022.

RES and the wholesale merit order process

The target model aims to meet electricity demand at the lowest cost by dispatching electricity producers based on their variable costs, a process known as *the merit order*. RES rank first in the merit order because of their low variable costs, which include maintenance expenses and no fuel costs. In contrast, fossil fuels have higher variable costs due to price volatility, market fluctuations, and CO_2 charges. These factors discourage their use in electricity generation. As RES have minimal operational expenses, their increase in power generation is expected to lower wholesale electricity prices (Peura and Bunn 2021).

Wholesale and retail electricity market prices



Source: ADMIE, ENTSO-E database

Wholesale electricity market prices

Wholesale prices entail the weighted average electricity cost within the interconnected system of the cost of the Day-Ahead and Intra-day Markets, deviations, and three surcharge accounts crafted within the Balancing Market and reflect the costs at which electricity is traded between generators, producers, and large consumers in the wholesale electricity market (admie.gr).

By August 2022, Greece experienced a significant peak in wholesale electricity prices, reaching 455 €/MWh, which marked a more than threefold increase compared to the previous year (ADMIE). The average wholesale electricity price for the entire year of 2022 settled at 307 €/MWh, reflecting annual growth rates of 127% for 2021 and 132% for 2022. Greece's day-ahead price, a component of the total wholesale price, has been higher than the EU average in recent years. In 2022, the Greek day-ahead price rose on average by 141% from 2021 to €279/MWh, surpassing the EU price of €231/MWh, which itself increased by 126% from 2021 (ENTSO).

Elevated energy prices, primarily driven by the cost of natural gas, contributed to historically high electricity market prices in Greece in 2022.

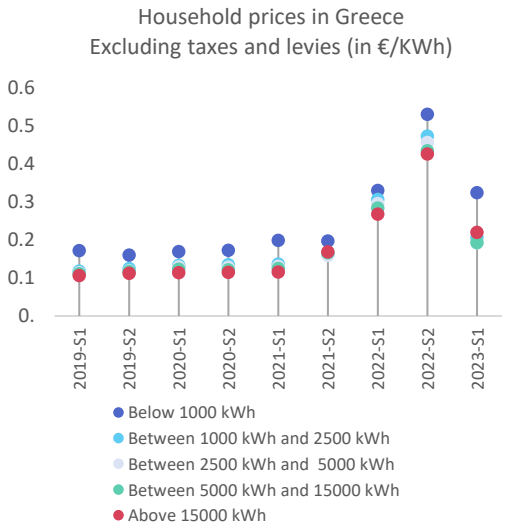
Retail electricity market prices

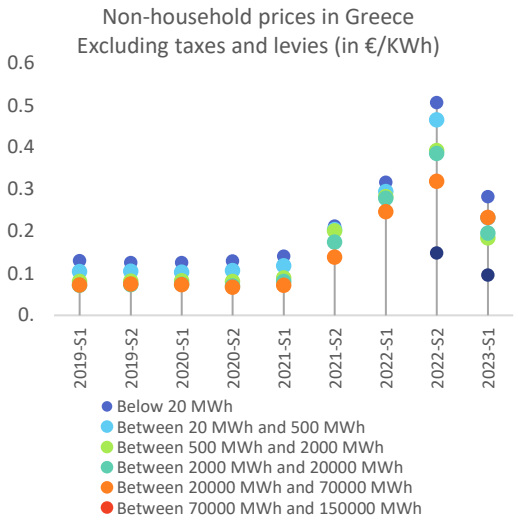
The prices established for final electricity consumption by households and non-households are the retail electricity prices. These are intrinsically linked to the wholesale electricity cost, although they can surpass it due to the inclusion of additional expenses and the incorporation of a profit margin that covers retail-related costs. Through electricity bills, consumers are billed for all activities associated with electrification, leading to higher retail prices, which reflect a spectrum of expenses, including production, supply, taxes, levies, subsidies, and regulated charges. These include charges for the Hellenic Electricity Transmission System and the Electricity Distribution Network, which cover transmission and distribution up to the consumer's property (rae.gr).

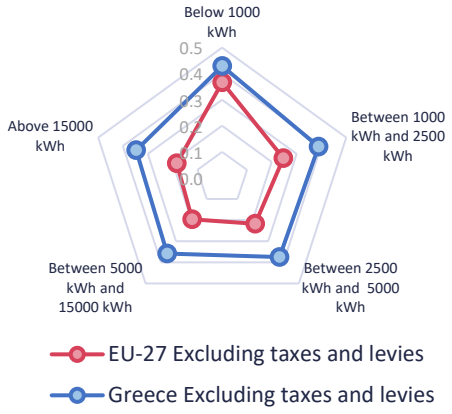
Eurostat breaks down reported prices into several components, which include a) energy and supply, b) network cost, c) VAT and d) other taxes, fees, levies and charges (ec.europa.eu/eurostat). In 2022, energy and supply costs, covering generation, aggregation, balancing, energy supply, customer services, and post-sales management, rose to 0.3348 €/kWh for households and 0.1063 €/kWh for non-households, up from 0.1207 €/kWh and 0.0337 €/kWh in 2021, respectively.

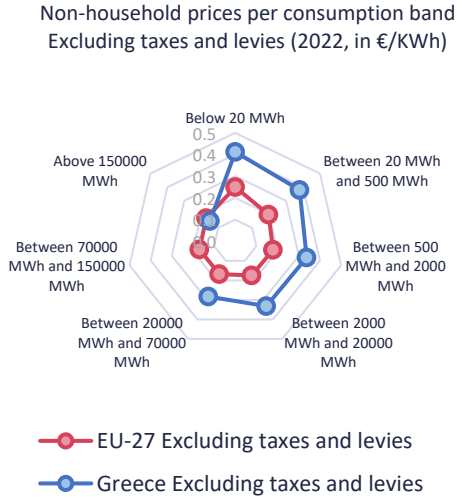
Network costs, i.e., transmission and distribution tariffs and losses, after-sale service, metering (cost of installing and maintaining meters that measure electricity consumption) and other, reached 0.0268 €/kWh for household and 0.0074 €/kWh for non-household consumers. In 2022, distribution costs accounted for 79% of network costs for households and 62% for non-households, with the rest being transmission costs. Renewable taxes, promoting RES, energy efficiency, and CHP generation, totaled 0.017 €/kWh for household consumers, while environmental taxes tied to air quality, CO_2 emissions, and other greenhouse gases were set at 0.0022 €/kWh.

Electricity prices for household and non-household consumers









* The graph legends correspond to the consumption bands of households and non-households respectively

Source: Eurostat, Electricity prices

In 2022, without the subsidies, Greece experienced some of the EU's highest electricity prices mainly due to its high reliance on imported natural gas.

Household consumer prices excluding taxes, levies and subsidies

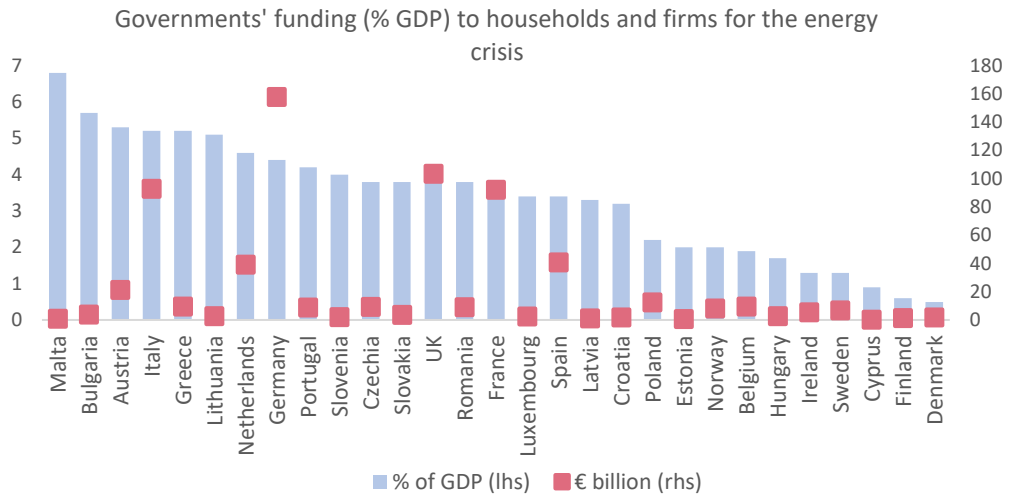
Eurostat reports bi-annual electricity prices for household and non-household final consumers, such as industry, services, offices, etc. Prices are denoted in €/kWh and are categorized into distinct consumption bands. Residential annual consumption spans five bands, ranging from below 1000 kWh to 15,000 kWh or higher. Nearly 40% of household consumption is attributed to medium-sized household consumers using between 2,500 and 5,000 kWh annually, while 1/3 to those consuming between 5,000 and 15,000 kWh.

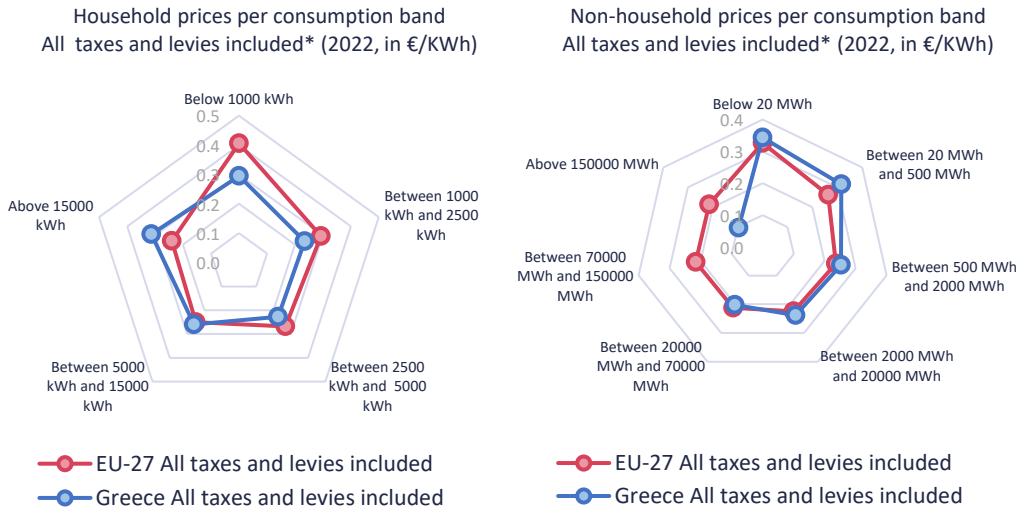
An evident trend emerges, illustrating an inverse relationship between household electricity prices and consumption, suggesting that lower consumption is associated with higher prices per kWh. In 2022, the cost of electricity for Greek households, excluding taxes, levies, subsidies, and allowances, ranged from 34.62 cents per kWh for those using over 15,000 kWh to 42.95 cents for consumption under 1,000 kWh. For medium-sized consumption, the electricity price stood at 37.53 cents/kWh, marking a significant 159% increase from 2021 and being 15.87 cents/kWh higher than the EU-27 average. In S1 2023, this price recorded a 35% annual reduction to 19.22 cents/kWh.

Industrial and commercial consumers excluding taxes, levies and subsidies

Industrial and commercial electricity consumption is classified into seven bands, spanning from under 20 MWh annually to over 150,000 MWh. Prices, excluding taxes and subsidies, varied from 14.89 cents/kWh for an annual consumption over 150,000 MWh to 41.22 cents/kWh for up to 20 MWh. For medium-sized non-household consumption (500 MWh to 2,000 MWh), the price stood at 33.78 cents/kWh, reflecting a 133% increase from 2021 and surpassing the EU average by 15.83 cents/kWh, which also increased by 90%. In S1 2023, a 35% price reduction was implemented, bringing the cost down to 18.45 cents/kWh.

Final electricity prices and measures to alleviate the impact of rising energy costs





* The graph legends correspond to the consumption bands of household and non-households respectively. Taxes, levies and subsidies are included.

Source: Eurostat, Electricity prices, Bruegel, National fiscal responses to the energy crisis

In 2022, Greece was among the EU countries which undertook significant measures to alleviate the impact of rising energy prices.

Final retail prices after taxes and subsidies

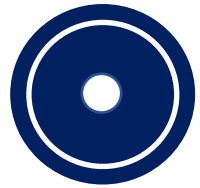
Energy prices in Europe soared after the Russia-Ukraine conflict in early 2022, leading to higher electricity bills. European governments provided allowances and subsidies to mitigate the increase. Thanks to these measures, the final price stood at 25.25 cents per MWh in 2022 for the Greek medium-sized businesses, slightly above the EU average of 23.58 cents/MWh. The final price of electricity for medium-sized household consumption dropped to 22.70 cents/kWh, below the EU average of 26.83 cents/kWh, marking a 14.83 cents/kWh difference compared to the respective price excluding taxes and subsidies. The overall increase in the final price of electricity for medium residential consumption when factoring in taxes and allowances was 24%, a stark contrast to the 159% increase that would have occurred without government intervention.

Measures to ease the burden of rising electricity and energy prices

The substantial measures taken to ease the burden of energy prices for Greek households and businesses also came at a significant cost to the fiscal budget. Until January 2023, energy support measures totaled €9.5 billion or 5.2% of the 2021 GDP, ranking it fifth among EU countries and exceeding support offered by over 40 OECD member states. Notably, nearly 74% of these measures were directed towards electricity-related initiatives (bruegel.org, ELIAMEP 2023).

The government implemented support measures for households and businesses, such as price reductions on electricity bills, eliminating the price adjustment clause, and offering subsidies and tax cuts for economically vulnerable individuals. However, these measures did not effectively curb excessive consumption, and many vulnerable households continued to face difficulties. In fact, half of Greek households reported being in arrears on their bills, which was the highest percentage in the EU (ELIAMEP 2023, eurofound.europa.eu).

Decarbonization, clean energy sources and energy transition

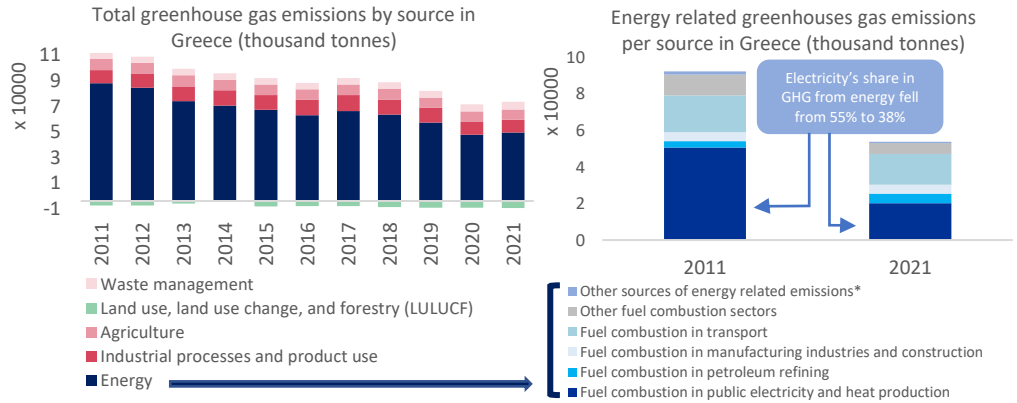


Decarbonization and the energy transition path

Carbon pricing

Fossil fuels carry a hidden cost as their combustion releases significant greenhouse gases into the atmosphere, contributing to climate change and harming both the environment and human health. However, the current market price of fossil fuels fails to account for this concealed cost. Carbon pricing addresses this issue by applying the principle of "polluters must pay," thereby reflecting the actual cost of fossil fuel combustion. By doing so, it can effectively curb emissions and promote the adoption of cleaner energy sources.

There are two main ways to implement carbon pricing: a) by levying a carbon tax on fossil fuels' carbon content and b) via an emissions trading system (ETS), known as "cap and trade" (rff.org). Carbon taxation means that the more carbon a fuel emits, the higher the tax will be. The ETS sets a cap on the total amount of emissions that can be released. Companies that emit less than their allotted amount can sell their surplus emissions allowances to companies that emit more. Greece, although it does not have a carbon taxation system, participates in the EU ETS, one of the world's largest carbon pricing schemes. In 2020, 56% of the country's CO_2 emissions were subjected to a carbon price (ourworldindata.org).



Source: Eurostat, Environmental database. Data processing Alpha Bank

The largest sectoral CO_2 emitters are electricity generation and transportation.

Greenhouse gas emissions and decarbonization for the energy transition

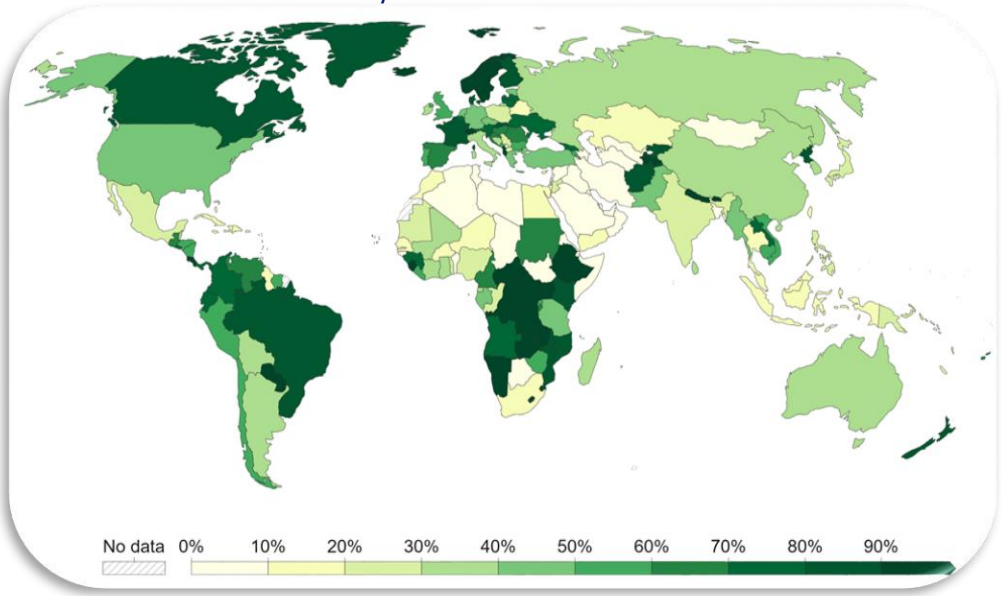
Between 2011 and 2021, Greece managed to reduce greenhouse gas emissions by 36%, bringing the total to 72 million tonnes in 2021, equivalent to 0.16% of global emissions (Eurostat, climatewatchdata.org). Greenhouse gases encompass various air pollutants, such as carbon dioxide (CO_2), methane, nitrous oxide and fluorinated gases. CO_2 is the largest gas contributor, responsible for 72% of emissions in Greece and around 76% globally (c2es.org).

In 2021, fossil fuel combustion for energy remained the largest contributor to CO_2 emissions, accounting for 74% of all emissions (82% in 2011). Other sources included industrial processes and product use (14%), agriculture (11%), and waste management (8%), all contributing to methane emissions. Land use and forestry, acting as CO_2 absorbers, exhibited a negative contribution (-8%). The largest emitter of the energy sector is fuel combustion in electricity and heat production due to the usage of fossil fuels. Electricity fuel combustion in Greece dropped by 60% during the decade 2011-2021, due to the limitation of lignite use and the parallel increase of natural gas and RES. However, it remains a significant polluter, emitting more than 20 million tonnes of greenhouse gases annually. In 2021, it accounted for 38% (from 55% in 2011) of energy-related emissions and 28% (from 45% in 2011) of overall emissions.

Since the Industrial Revolution, human-caused CO_2 emissions have greatly accelerated, especially over the past 70 years, reaching record levels. This has significantly contributed to climate change, leading to a rise in the Earth's average temperature. As fuel combustion remains the primary source of CO_2 emissions, transforming the energy sector, particularly electricity generation and transportation, becomes crucial in mitigating climate change. On a global scale, about 28% of electricity is now generated from renewable energy sources, which release only minimal greenhouse gases into the atmosphere (un.org, iea.org).

The global landscape of clean energy technologies

Share of electricity from low-carbon sources in 2022*



*Low-carbon electricity from renewable sources (solar, wind, hydropower, biomass and waste, geothermal, wave and tidal) and nuclear power.
Source: ourworldindata.org

Renewable energy sources in China's electricity industry

In 2022, China recorded the world's largest power generation, exceeding the combined annual generation of the USA, the EU and Japan. This feat came with a significant environmental impact, as China emerged as the largest greenhouse gas emitter, responsible for 14% of CO_2 energy-related emissions worldwide. However, China's power sector is being transformed, with renewables corresponding to more than 30% of its power generation mix in 2022. China's installed RES capacity exceeded that of coal-fired plants in 2022. China solidified its leadership position in renewable energy, with a 28% increase in solar PV capacity and 11% in wind power (IEA 2023, IRENA 2023, Stochasis 2022).

RES utilization in electricity generation has expanded markedly over time.

Expansion of renewable energy sources on a global scale

The global share of RES in power generation rose from 20% in 2010 to 30% in 2022. RES installed capacity represented 40% of the global total, with 83% of new additions originating from RES, a substantial rise from 37% in 2010. Hydropower, generated through dams and other structures, is the largest renewable electricity source, contributing 15% of global electricity generation. Solar PVs also play a notable role, as they grew 26-fold from 2010, accounting for 4% of global electricity generation and 14% of RES generation, making up 65% of new RES capacity. Wind power installations surged fivefold from 2010, while in 2021 they covered 6.6% of global power needs (IEA 2023, IRENA 2023, elements.visualcapitalist.com). Despite the growth of RES, the global power system still contributed to 40% of CO_2 emissions, reaching a record high and indicating that we are still far from offsetting the continued use of fossil fuels.

Clean energy use in the EU

Europe's use of RES dates back to the 18th century, with the world's first hydroelectric project developed in England in 1878. Denmark installed the first offshore wind farm in Vindeby in1991 and the first large-scale offshore wind farm in 2000. As of 2022, the EU power generation corresponded to 14% of global total generation, producing 8% of global energy-related CO_2 emissions.

The share of clean energy (RES and nuclear fuels) in total electricity production stood at 57% in 2021, up from 47% in 2011, with 25% attributed to nuclear fuels and 32% to renewables (wind: 13%, hydro: 13%, solar: 6%). This is in line with the at least 32% target of RES use in electricity generation for the EU up to 2030. Across all EU countries, there is a widespread use of RES for electricity production, with Austria leading at 74% and Luxembourg close behind at 71%. Additionally, 13 countries incorporate nuclear fuels into their energy mix, with France having the highest utilization rate at 68%.

Clean fuels and cutting-edge technologies supporting a low-carbon transition

Exploitation of hydro, solar, wind and geothermal technologies' potential

Forecasts for RES technology expansion between 2022 and 2027 anticipate an additional capacity of 2,400 GW, a figure almost equal to their expansion over the entire decade 2001-2021, nearly half of which is expected to come from China (IEA, Renewables 2022). If these predictions are verified, RES will account for 90% of electricity capacity expansion globally during this five-year period.

Between 2022 and 2027, wind and solar energy capacity are expected to lead the growth in renewable sources. Wind power capacity is set to nearly double, driven in part by offshore installations, while solar PVs are projected to nearly triple their current capacity by 2027, making them the primary source of renewable energy capacity according to IEA's Renewables 2022 report. Additionally, concentrated solar power systems (CSP) are promising, using reflected sunlight to generate dispatchable energy that can be used instantly or stored, in contrast to PV technology (energy.gov). Greece enacted its inaugural offshore wind legislation, the Offshore Wind Energy Bill in August 2022, establishing a goal of achieving 2 GWh of floating offshore wind power by 2030. The Greek government has also set as an objective to fund 250,000 small PV installations on the rooftops of residences and businesses, enabling them to utilize their self-generated energy at no cost (bruegel.org).

Geothermal energy is another renewable source used for both electricity generation and heating. By boiling water in underground reservoirs with heat from the Earth's core and converting it to steam via pumps, geothermal energy produces less than 1% of global electricity. Greece boasts significant geothermal capacity due to its geological characteristics, with geothermal fields spreading throughout the country, the most notable of which are those in Milos, Nisyros, Lesvos, and Santorini. Despite its significant geothermal potential, the exploitation of geothermal energy in Greece remains limited. To tap into the geothermal potential, further investment and development of geothermal projects are required (thinkgeoenergy.com).

The energy crisis prompts a shift to RES, driven by their increased competitiveness and national policies to strengthen energy security.

Carbon sequestration technologies

Carbon capture, utilization and storage (CCS or CCUS) is a promising new technology that captures carbon dioxide emissions directly from the atmosphere or from a point source, such as power plants or industrial facilities, and stores them underground or uses them by converting carbon to make products such as building materials, chemicals, fuels etc. (iea.org, nationalgrid.com). When captured, CO_2 is compressed and transported to a storage site, where it is injected into deep underground formations, such as depleted oil and gas reservoirs (energy.ec.europa.eu).

CCS technologies can hep mitigate climate change, but they are currently in the early stages of development, with challenges such as cost and the availability of storage sites to be addressed before they can be widely deployed. Today, CCS technologies can globally capture over 40 Mt of CO_2 per year (iea.org).

Energy storage, hydrogen and electrification

The future of transport electrification relies on energy storage technologies like lithium-ion batteries and applications using hydrogen for electricity production. These technologies are expected to gain critical momentum in the coming years. Fuel cell electric vehicles (FCEVs), which utilize hydrogen gas to produce electricity through fuel cells, are currently under development (Miller and Spooman 2015). Hydrogen gas can also be utilized in power and heat generation, steel and iron production, oil refining, and biofuel production (IEA 2022). However, for hydrogen to be considered a clean fuel, it should be produced from low carbon emission sources ("green hydrogen") as it is rarely found alone in the atmosphere as an element. In 2021, although 94 Mt of hydrogen was produced globally for various purposes, less than 1% was generated via low-emission sources (IEA 2022).

Policy recommendations and SWOT analysis

Policy recommendations for a sustainable energy transition

Enhanced focus required on economically viable renewable energy options

The Paris Climate Agreement to keep temperature increase at 2°C or at best at 1.5°C until 2050 remains a challenge for humanity. Each country can contribute to achieving this goal by reducing its own carbon emissions. Greece has also committed to complying with these objectives in its national climate plans by setting its own targets for the share of renewables in the electricity mix, the carbon dioxide emissions reduction target, or the lignite phase-out in electricity generation, aligned with the European goals. Energy transition for Greece, as evidently for many other countries, is a necessary condition to achieve the climate targets but also to increase energy security and limit the dependency on fossil fuels and energy imports.

RES are pivotal in energy transition, in both electricity generation and direct use in transport, heating, and cooling. These technologies contribute to improved energy efficiency and cost reductions. Implementing domestic policies to scale up the use of RES, along with pricing tools like carbon taxation, can effectively curb emissions. Revenues generated from such measures can fund renewable energy projects and incentivize low-emission practices for products and firms. Gradually increasing carbon prices over time can also accelerate the adoption of cleaner energy alternatives (imf.org, unfccc.int, IRENA 2023, IEA 2018). International coordination policies for carbon pricing, including the establishment of a carbon price floor, can facilitate negotiations among major emitting countries and establish a minimum carbon price for each nation (IMF 2021).

End-users can significantly impact the demand for RES and clean energy technologies by choosing renewable energy products and services and by advocating for policies that promote energy transition. By raising climate change awareness and providing incentives like tax deductions or price reductions, consumers can play a vital role in driving energy savings through choices such as electric boilers, heat pumps, energy-efficient renovations, and the wider adoption of electric vehicles (iea.org, eefig.ec.europa.eu).

A sustainable energy shift embraces cleaner energy in a cost-efficient manner.

Clean transition requires sustainable investments, research and innovation

Clean energy transition requires pivotal investments in the coming decades, not only for building infrastructure but also for advancing research and innovation. Both the private and public sectors can contribute funds and support to this endeavor. National research initiatives have the potential to cultivate expertise in key technologies and facilitate participation in global collaborations (IEA 2018). The projected investment for energy transition is $150 trillion by 2050, distributed across various domains: energy conservation and efficiency (29%), renewable power generation capacity (26%), supporting infrastructure for RES (e.g., power grids, energy flexibility) (15%), electrification of end uses like transportation (11%), direct utilization and production of RES technologies (4%), green hydrogen (3%), and carbon removal technologies (2%) (IRENA 2023).

Investment activity in energy transition in Greece is appointed to direct €43.8 billion up to 2030 for energy efficiency, electricity generation from RES, electrical system infrastructure, digitalized infrastructures for the electricity distribution network and new thermal electricity generation plants and central storage plants (NECP 2019). Research, innovation and investments in new technologies, such as tapping into the potential of geothermal energy sources or the creation of underground carbon emissions storage sites in Greece, must be addressed.

ESG factors as a sustainable investment tool in the financial sector

Financial sector investors are tasked with taking into consideration various environmental factors when applying ESG (Environmental, Social, Governance) criteria in their investment decisions. Sustainable and green investment opportunities with climate-related objectives and carbon reduction goals must be identified and pursued. Sustainable finance evaluates companies' disclosure on risks and opportunities regarding energy efficiency, carbon footprint and strategies that apply RES or support their use (OECD 2021).

SWOT analysis of the power market in Greece

ALPHA BANK

STRENGTHS

Prominent growth of renewable energy sources (RES) within the electricity generation mix, coupled with escalating investments in RES.

Greece possesses abundant potential in RES, particularly wind and solar energy.

The liberalized electricity market stimulates competition among private investors engaged in production and supply.

Anticipated completion of the electricity grid expansion across diverse islands, like Crete, by 2025.

The decommissioning of numerous lignite-powered plants contributed to lowered greenhouse gas emissions from power generation.

Efforts to integrate the Greek electricity market into the EU market.

WEAKNESSES

Despite the advancement, the delignitization in the Greek power sector still has a considerable distance to cover.

Carbon taxation has not yet been adopted in Greece as a means of curbing greenhouse gas emissions.

Progress in infrastructure for vehicle electrification remains modest.

Resistance to change and reluctance to embrace RES projects like wind turbines in certain areas.

Vulnerabilities tied to reliance on imported fossil fuels underscored by the recent energy crisis.

Energy storage systems pose a challenge due to their elevated costs.

OPPORTUNITIES

Greece as a hub for energy trade and collaboration.

Promising geothermal resources for power generation.

Potential for offshore wind parks, with careful consideration of the impact on the marine ecosystem.

Clean hydrogen investments.

Ambitious national targets for RES penetration in electricity.

Enhanced regulatory framework and infrastructure.

Funding options for RES and electricity projects in the NRRP.

Decreasing RES costs and investment expenses.

Rising adoption of energy-efficient technologies.

Development of a smart electricity grid.

THREATS

Electricity prices are susceptible to fluctuations in fossil fuel costs and carbon pricing volatility.

Inflationary concerns and fuel price volatility due to geopolitical tensions.

Urgent responses required for climate-related risks, including Greece's susceptibility to extreme weather events.

Challenges posed by expensive and limited materials, like lithium-ion batteries, for energy storage.

Increasing electricity demand juxtaposed with an excessive dependence on intermittent energy sources, lacking sufficient storage capabilities.

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Appendix: list of abbreviations

ACER: Agency for the Cooperation of Energy Regulators

CCUS/CCS: Carbon Capture, Utilization and Storage

CHP: Combined Heat and Power

CO_2: Carbon Dioxide
CSP: Concentrated Solar Power

DAPEEP: Operator of RES and Guarantees of Origin

EBITDA: Earnings Before Interest, Taxes, Depreciation and Amortization

EC: European Commission
ELAPE: RES CHP Account

ENTSO: European Network of Transmission System Operators

EP: European Parliament

ESG: Environmental, Social, Governance

ETS: Emissions Trading System

ETSS: Energy Trading Spot System
EU: European Union
FCEV: Fuel Cell Electric Vehicles
FIP: Feed-In-Premium

FIT: Feed-In-Tariff

GDP: Gross Domestic Product
GVA: Gross Value Added

HCAP: Hellenic Corporation of Assets and Participations

HEDN/EDDIE: Hellenic Electricity Distribution Network

HEDNO/DEDDIE: Hellenic Electricity Distribution Network Operator

HEnEx: Hellenic Energy Exchange Market

HETS/ESMIE: Hellenic Electricity Transmission System

IEA: International Energy Agency
IMF: International Monetary Fund

IPTO/ADMIE: Independent Power Transmission Operator

JTF: Just Transition Fund

LAGIE: Hellenic Electricity Market Operator

NACE: Statistical classification of economic activities in the European Community
NECP: National Energy Climate Plan

NEMO: Nominated Electricity Market Operator

NII: Non-Interconnected Islands

NRRP: National Recovery and Resilience Plan
NSRF: National Strategic Reference Framework

NTJTP: National and Territorial Just Transition Plan

OECD: Organization for Economic Cooperation and Development

OTC: Over-The-Counter

PBT: Profit Before Taxes

PPC/DEI: Public Power Corporation
PV: Photo Voltaic
RAAEY: Regulatory Authority for Waste, Energy and Water
RAE: Regulatory Authority for Energy

RED: Renewable Energy Directive

RES: Renewable Energy Sources
RRF: Recovery and Resilience Fund

SMP: Special Market Price

TOU: Time-Of-Use

TTF: Title Transfer Facility

UN: United Nations

VAT: Value Added Tax

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