Greece 2023

Energy Policy Review

International Energy Agency

INTERNATIONAL ENERGY AGENCY

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Foreword

The mission of the International Energy Agency (IEA) is to shape a secure and sustainable energy future for all. We work with countries around the world to strengthen energy security and reach net zero emissions. Our in-depth reviews are an essential IEA tool for providing insight and advice to governments on how to best achieve their energy and climate goals.

Greece is to be commended for its response to the global energy crisis triggered by Russia's invasion of Ukraine. It has sought to reduce its reliance on Russian energy by increasing imports from other countries, raising domestic renewable energy production, and reducing energy demand through greater efficiency. Its actions to protect vulnerable consumers from high energy prices are particularly noteworthy. I am glad to have had the opportunity to meet with Prime Minister Kyriakos Mitsotakis, Minister of Environment and Energy Kostas Skrekas, and other members of the Government over the past year to assess developments in the crisis and share the IEA's analysis and advice.

Our latest review commends Greece for its National Climate Law, which sets ambitious decade-by-decade targets for bringing down greenhouse gas emissions to net zero by 2050. Greece has made notable progress towards meeting these goals, including significantly reducing the share of lignite in its power mix, and setting a binding target to end the use of lignite for electricity generation by 2028. At the same time, Greece has taken clear steps to ensure a just transition in its lignite-mining regions. Despite these successes, challenges remain – fossil fuels still account for most of Greece's energy supply and stronger efforts are needed on energy efficiency.

I hope that the recommendations set out in this report will help Greece accelerate its energy transition while ensuring affordable and secure energy supplies.

Dr. Fatih Birol

Executive Director

International Energy Agency

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Executive summary

Greece's energy and climate policies are centred on achieving net zero emissions by 2050 while ensuring energy security, improving economic competitiveness and protecting vulnerable consumers. The National Energy and Climate Plan (NECP), adopted in 2019, is the main document setting energy and climate policy through 2030 and includes targets and supporting measures to put the country on a path to net zero emissions. The National Climate Law, adopted in May 2022, sets targets to reduce total greenhouse gas (GHG) emissions by 55% by 2030, by 80% by 2040 and to reach net zero emissions by 2050. It defines key emissions reduction measures, including the phase-out of lignite-fired generation by 2028.

Greece has seen a reduction in the share of fossil fuels in its energy supply, mainly because of decreasing use of lignite for electricity generation. However, fossil fuels are still the dominant energy source in Greece, and strong efforts are needed to reduce fossil fuel demand in line with GHG emissions targets. From 2010 to 2021, the share of fossil fuels in energy supply fell from 90% to 82% of total energy supply (compared to an IEA average of 78% in 2020). From 2005 to 2021, the share of lignite-fired generation fell from 60% to 10%, driving down the carbon intensity of electricity generation. The decline in lignite-fired generation was offset mainly by increased gas-fired generation, along with growth in generation from wind and solar photovoltaics (PV).

Greece achieved most of its 2020 energy and climate targets. However, a significant share of the reduction in energy demand and GHG emissions was caused by Greece's prolonged economic contraction following the 2008 crisis and the Covid-19 pandemic. Greece has reduced the carbon intensity of its economy, but an increase in demand following the lifting of pandemic restrictions in 2021 is already leading to increased GHG emissions.

Looking forward, Greece's energy policy focuses on boosting the use of renewable energy, especially for electricity generation, in tandem with increasing the share of energy demand covered by electricity, especially for transport and heating and cooling. Greece recently made several significant changes to its support scheme for renewable electricity generation to increase the rate of deployment and ensure low electricity prices. Greece is also taking steps to reduce the time needed for licensing and permitting projects for renewable energy, electricity infrastructure and energy storage. In August 2022, Greece approved its first Offshore Wind Law, which aims for 2 gigawatts (GW) of offshore wind capacity by 2030. Renewable energy in transport comes mainly from a biofuel blending mandate. Greece is a global leader in the use of solar thermal to cover building hot water demand.

Greece is planning major investments in electricity infrastructure. This includes expanding interconnection capacity to increase integration with the European electricity market and support the goal of becoming a net electricity exporter. The government has announced plans to double the capacity of interconnections with Bulgaria, Italy and North Macedonia;

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triple the capacity of interconnections with Albania; and establish an interconnection with Egypt. There are also major investments planned to boost domestic transmission and distribution capacity to support much higher levels of generation from wind, solar PV and hydro. The government also aims to connect the most populated islands to the mainland electricity grid by 2030.

To ensure the efficient and effective functioning of its electricity market, Greece finalised major reforms in 2020 to introduce three wholesale electricity spot markets (day-ahead, intraday and balancing) and a derivatives market. Greece has also completed several reforms to support full integration in the European common electricity market, including joining the intraday European market coupling in December 2022 and opening its market to demand response in September 2022. Greece's gas market has also undergone major changes in recent years, with the opening of a natural gas spot market in March 2022 as a key achievement.

The government aims to increase energy efficiency in all sectors, with the NECP defining a wide range of energy efficiency measures. An energy efficiency obligation scheme provided higher energy savings than expected between 2017 and 2020, but Greece fell short of achieving its overall energy-saving target for this period. Building on the experience of other IEA member countries, Greece could improve the scheme and increase energy savings through 2030. As the Greek building stock is older than the EU and IEA average, it presents a notable opportunity to achieve energy savings. Existing measures for buildings include stricter building codes and a variety of incentives for thermal renovations, upgrading heating and cooling systems, and replacing appliances with more efficient ones. The stock of vehicles on Greek roads is also among the oldest in the European Union (EU). In the transport sector, subsidies and fiscal measures aim to increase the adoption of electric vehicles (EVs), while local authorities are obliged to prepare plans to promote a modal shift away from private vehicles to public transit, cycling and walking. Industry sector measures consist mainly of energy demand audits. Additional efforts are needed to realise the full potential of energy efficiency in all sectors, supporting energy security and climate targets.

The government sees energy research and development (R&D) as important to achieving 2030 climate targets and the long-term net zero emissions goal. The NECP provides an overview of research areas the government deems most critical to achieving energy and climate goals. These include new technologies for renewable electricity generation; electricity transmission, distribution and storage; heating and cooling; energy efficiency in buildings and industry; low-cost smart electromobility; advanced biofuels; and GHG reductions through low-emission technologies in industry. Greece has a long history of scientific excellence, concentrated in a small number of public institutions; however, significant effort is needed to boost the level of energy R&D in Greece and ensure it is aligned with the net zero emissions goal.

There is a policy focus on reducing oil demand, which comes mostly from the transport sector. Reducing oil demand from road transport is achieved mainly through a biofuel blending mandate and also through increasing support for EVs. Oil is also a key fuel in the building sector, covering around a quarter of building energy demand in 2020. There are policy efforts to reduce oil-fired building heating. From 2025, the installation of oil boilers will no longer be allowed, and from 2030, oil for heating will have to contain at least 30% by volume of renewable liquid fuels. Greece continues to rely on oil for a notable share of its electricity generation – 7% in 2021 – compared to the IEA average of 2% in 2020.

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Oil-fired electricity generation is used mainly on Greek islands, with the government aiming to phase out most oil-fired generation by 2030 by interconnecting islands to the mainland electricity grid and the deployment of renewables on islands.

Key policy documents (most of which were approved before 2021) give natural gas a major role in reducing lignite-fired generation and oil demand from building heating and industry. Following the Russia Federation's (hereafter "Russia") invasion of Ukraine and the sustained increase in gas prices, the government is re-evaluating the role of gas in the Greek energy system. However, the future of natural gas in the Greek energy system remains unclear, with major steps being taken to reduce gas demand in line with climate and security goals while at the same time large investments are planned to expand gas infrastructure, which could lead to higher gas demand.

The government aims to use energy taxation to drive energy transition. Greece's effective tax rates on CO_2 emissions from energy use are high compared with other OECD countries. However, tax rates vary across fuels and uses, as well as tax concessions, and provide inconsistent carbon price signals that are not well aligned with Greece's climate goals. There are numerous exemptions and reductions to energy taxation, many of which lower the cost of fossil fuels. In addition, electricity bills include a wide range of fees and charges, many of which have no relation to consumers' electricity use. This reduces the incentive to save energy and makes electrification a less attractive option. As an EU member state, Greece has committed to eliminate fossil fuel subsidies. However, the OECD estimates that in 2020, Greece provided over EUR 1.9 billion in fossil fuel subsidies. From 2015 to 2020, fossil fuel subsidies decreased by 14% because of reductions in direct transfers supporting oil-fired electricity generation on non-interconnected islands and lower spending on heating allowances. Although decreasing, fossil fuel subsidies were still equivalent to more than one-quarter of energy tax revenue, among the highest share in the OECD.

Covid-19 response

In response to the Covid-19 pandemic, the European Union established the Recovery and Resilience Facility, which provides EUR 724 billion through 2026 to support recovery and resilience plans developed by each EU member state. Greece was among the first EU member states to submit a plan, in April 2021. The plan (Greece 2.0) is one of the largest funding requests to the Recovery and Resilience Facility (EUR 30.5 billion, equivalent to 16.7% of Greece's 2019 gross domestic product [GDP]). The plan funds energy efficiency subsidies for residential buildings (EUR 1.1 billion), businesses (EUR 0.45 billion) and the public sector (EUR 0.2 billion). In the electricity sector, there is funding to deploy 1.4 GW of electricity storage (EUR 0.45 billion), interconnect the islands (EUR 0.2 billion) and upgrade electricity distribution networks (EUR 0.1 billion). The plan also includes EUR 0.2 billion to instal 8 656 publicly accessible EV charging points, deploy 220 electric buses and replace older taxis with EVs. The plan further includes EUR 0.3 billion for energy research, development and demonstration (RD&D) relating to EVs and the development of Greece's first CO_2 storage facility. The plan also supports the implementation of a variety of energy sector reforms, including improvements to the main financing mechanism for renewables and co-generation and to licensing and spatial planning for renewables.

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Addressing energy poverty and high energy prices

Greece's NECP notes that energy poverty has been increasing and that reducing it is an important policy priority; the objective is to reduce it by at least 50% by 2025 and bring it below the EU average by 2030. The government estimates that in 2021, 17.5% of the total population and 36.7% of economically vulnerable consumers were unable to adequately heat their homes; these figures are higher than the 8% average for the European Union. In September 2021, Greece released an Action Plan to Combat Energy Poverty, which gives a quantitative definition of energy poverty and defines a broad strategy backed by specific measures to reduce energy poverty. The social tariff (established in 2010) is the main policy tool to address energy poverty. It provides discounted electricity rates to several categories of economically or socially vulnerable residential consumers. The government estimates that in 2019, 500 000-550 000 households benefited from the social tariff.

Starting in late 2021, global energy prices began to increase rapidly, especially in Europe. Price spikes and high volatility persisted into 2022, driven mainly by the impacts of Russia's invasion of Ukraine. Greece has taken numerous steps to limit the impact of high energy prices, especially for vulnerable consumers. The Greek efforts include expanding existing measures targeting energy poverty and introducing broader measures to reduce energy prices for most consumers. From September 2021 to November 2022, Greece dedicated EUR 9 billion to energy subsidies and other measures to help consumers pay utility bills. Most of this support is delivered through the Energy Transition Fund, established in 2021 to fund a variety of subsidies for electricity, natural gas, heating oil and transportation fuels to combat energy poverty and reduce the impact of high energy prices.

Reducing dependence on Russian fossil fuels

Greece has notable dependence on fossil fuel imports from Russia. In 2021, Russia accounted for 96% of hard coal imports, 41% of natural gas imports, 21% of crude oil imports and a small share of oil products imports. Hard coal imports are used mainly in the industry sector, primarily for steel production. Gas-fired generation plays a key role in the Greek electricity system, and gas is also important for building heating and industry. Greece is taking strong steps to decrease national and EU dependence on Russian energy imports.

A new floating storage unit at the liquefied natural gas (LNG) terminal started operations in August 2022; thanks to the new unit, LNG cargoes have doubled year-on-year, while imports from Russia have dropped from 40% to less than 20% of Greece's gas supply. One of Greece's major gas importers has signed a deal that could substitute almost 100% of Greece's remaining gas imports from Russia. Construction of a new floating LNG terminal started in May 2022; it should be operational by the end of 2023 and would almost double Greece's LNG import capacity. There are additional LNG terminal projects under consideration. Greece increased lignite stockpiling to serve as a security reserve in case of disruptions in the gas supply. Since the Russian invasion of Ukraine, Greece has also notably increased efforts to deploy renewables and increase energy savings as key tools to reduce reliance on Russian energy.

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Key recommendations

The government of Greece should:

- Reassess the need for investments in fossil fuel infrastructure, taking into account the risk of stranded assets and the need to direct limited capital to investments supporting the energy transition.
- Ensure transparent and stable legal and regulatory frameworks, which enable renewables and electricity infrastructure projects to be implemented within a reasonable time frame. Streamline the procedures for spatial planning and licences to facilitate the timely deployment of projects.
- Adjust taxes, market regulations and financial support measures so that energy prices drive behaviour and investment towards a just energy transition, increase system flexibility and reduce the risk of stranded assets.
- Focus building renovation programmes on deep renovations that combine thermal insulation with heat pumps to deliver maximum benefits for energy savings and reducing bills. Vulnerable households should receive priority and adequate resources.
- Promote the replacement of old vehicles, especially freight trucks, by providing incentives, including a scrapping programme to trade-in older vehicles for more efficient ones.

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1. General energy policy

Key data

(2021)

TES: 851 PJ in 2021, -24% since 2011

TES by source: oil 46.6%, coal 8.4%**,** natural gas 26.8%, solar and wind 8.2%, bioenergy and waste 6.0%, hydro 2.5%, electricity imports 1.6%

Energy intensity per capita (TES/capita): 79.8 GJ/capita (IEA average: 167 GJ/capita); -21% since 2011

Energy intensity per GDP (TES/GDP): 2.86 MJ per USD (IEA average at 3.78 MJ per USD); -19% since 2011

TFC: 637 PJ; -20% since 2011

TFC by sector: buildings 38.7%, transport 36.4%, industry 24.9%

Country overview

Greece's energy and climate policies are centred on transitioning to a net zero emissions economy by 2050 while ensuring energy security, improving economic competitiveness and protecting vulnerable consumers. The NECP, adopted in 2019, is the main document setting energy and climate policy through 2030 and includes targets and supporting measures to put the country on a path to net zero emissions. The National Climate Law, adopted in May 2022, sets targets to reduce total GHG emissions by 55% by 2030, by 80% by 2040 and to reach net zero emissions by 2050. It defines key emissions reduction measures, including the phase-out of lignite-fired generation by 2028. The recovery and resilience plan, Greece 2.0, defines the main steps to address the impacts of the Covid-19 pandemic and includes major funding for energy sector projects and reforms focusing on energy transition.

Greece's plans for energy transition focus on increasing generation from renewables, especially wind and solar PV, coupled with electrification of energy demand, especially for building heating and cooling, and transport. Greece also intends to improve energy efficiency in all sectors. The NECP and other policy documents aim to greatly reduce reliance on lignite and oil but give a major role to natural gas, especially in electricity generation, building heating and industry. Following the Russian invasion of Ukraine and sustained high gas prices, the government is re-evaluating the role of natural gas in the energy system, but exact plans for gas remain unclear, with some strong steps taken to reduce gas demand (increased support for renewables and energy efficiency) while others support increased demand (planned investments to expand the gas network).

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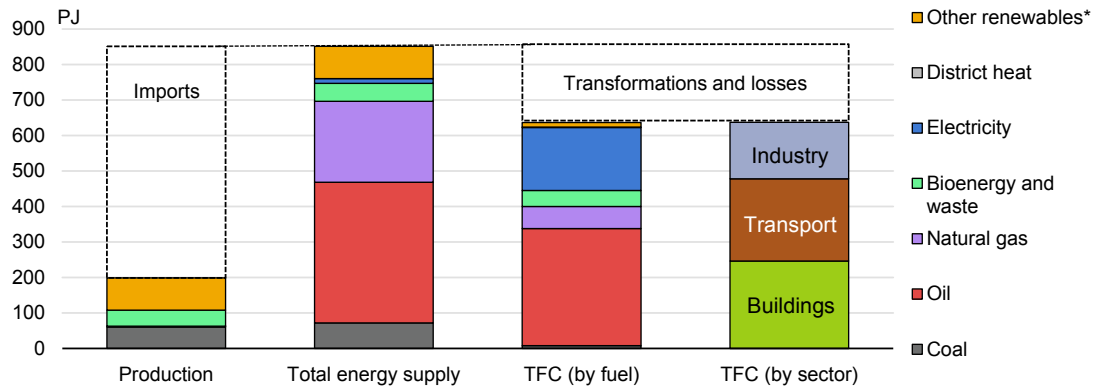
Energy supply and demand

Greece is reliant on imported fossil fuels to cover most of its energy demand (Figure 1.1). Historically, a notable share of electricity demand was covered by lignite-fired power plants located next to lignite mines in the north of Greece. However, domestic lignite production has steadily declined as Greece phases out lignite-fired generation. From 2011 to 2021, domestic lignite production dropped from 314 petajoules (PJ) to 60 PJ. Over the same period, domestic energy production from renewables grew from 86 PJ to 136 PJ, mainly because of increasing electricity generation from wind and solar PV. Greece produces only a marginal amount of oil (2.4 PJ in 2021) and natural gas (0.2 PJ) but has indicated interest in increasing domestic oil and gas production. From 2011 to 2019, Greece's total energy supply (TES) decreased by 18%, from 1 122 PJ to 924 PJ, driven mainly by the prolonged contraction of the economy.

Figure 1.1 Energy production, supply and demand in Greece, 2021



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* *Other renewables* include wind, solar, hydro and geothermal. Source: IEA (2022).

In 2020, TES dropped by 11% to 824 PJ, mainly due to the greatly reduced transport energy demand resulting from the Covid-19 pandemic. It rose again to 851 PJ in 2021 (Figure 1.2). Greece has seen a reduction in the shares of fossil fuels in its energy supply, but fossil fuels are still the dominant energy source. From 2011 to 2021, the combined shares of fossil fuels in TES fell from 91% to 82% of TES (compared to an IEA average of 78% in 2020). Oil covers the largest share of TES, and from 2011 to 2021, the share of oil in TES fluctuated around the average of 47%. Over the same period, a transition from lignite-fired generation to gas-fired generation reduced the share of coal in TES from 29% to 8.4%, while the share of gas in TES increased from 15% to 27%. From 2011 to 2021, the share of solar and wind in TES steadily increased, from 2.2% to 8.2%, and the share of bioenergy and waste grew from 4.8% to 6%. The share of electricity imports fluctuated between 0.6% and 3.9%. Electrification of energy demand is increasing. From 2011 to 2021, the share of energy demand (TFC) covered by electricity increased from 23% to 28% (compared to an IEA average of 23% in 2020).

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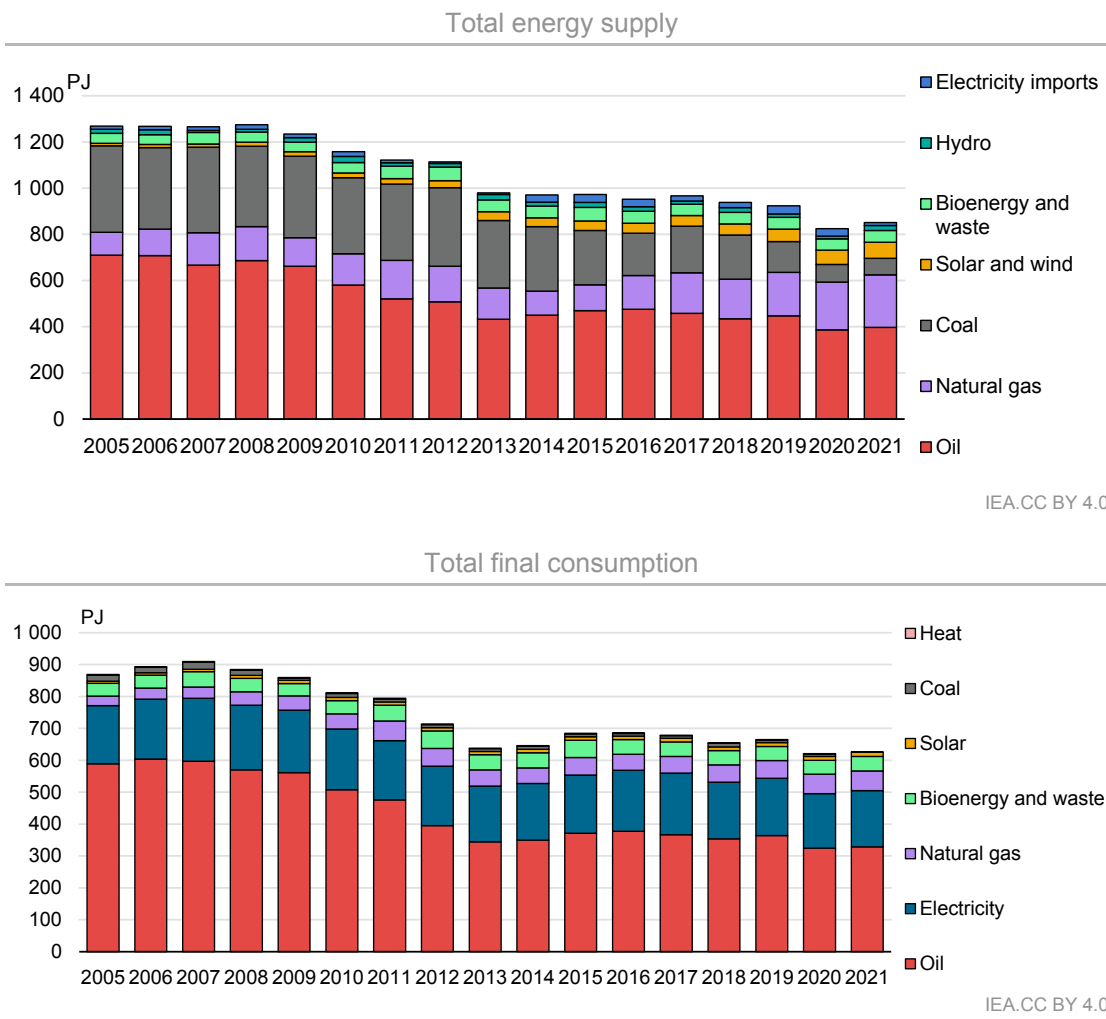
Figure 1.2 Total energy supply and demand by source in Greece, 2005-2021



Source: IEA (2022).

Buildings account for the highest share of Greece's TFC (Figure 1.3). A notable share of buildings demand is covered by electricity, 50% in 2021, compared to the IEA average of 44%. Greece also has a high use of oil for building heating. Oil covered 21.1% of buildings energy demand in 2021, much higher than the IEA average of 9.7%. Thanks to multi-decade policy support for solar thermal collectors, Greece is a leader in the share of building energy demand covered by solar thermal (5.1% in 2021, compared to the IEA average of just 0.6%).

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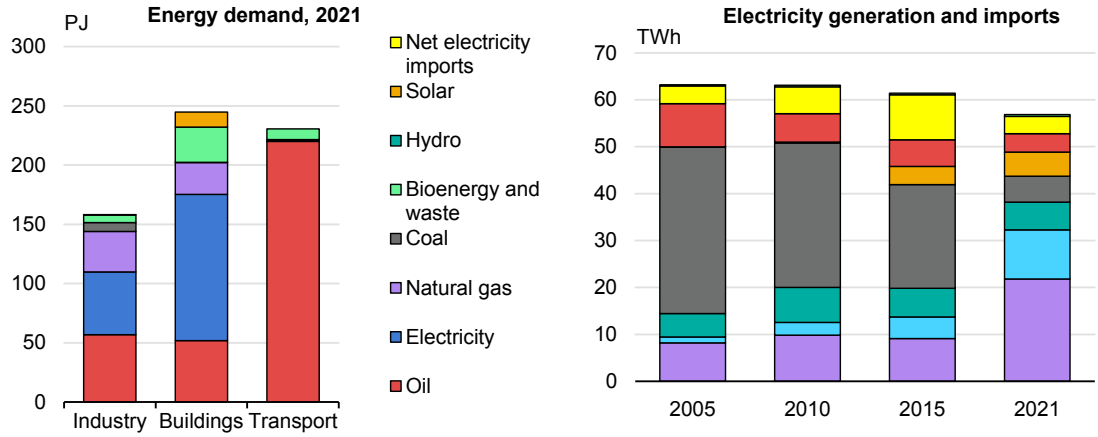
Figure 1.3 Greece's energy demand by sector and fuel, and electricity generation by fuel, 2005-2021



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Source: IEA (2022).

As in many IEA member countries, Greece's transport sector remains almost completely reliant on oil, which covered 95.4% of transport TFC in 2021, while a small share was covered by biofuels blended with diesel and gasoline (3.9%). A very low share was covered by electricity (0.3%, mainly in rail), compared to the IEA average of 0.9%. Greece only has a limited deployment of EVs, which accounted for just 0.2% of passenger vehicles in 2020 (versus the EU average of 1.6%).

Industry accounts for a relatively low share of TFC, reflecting the Greek economy's focus on the service sector. In 2021, industry accounted for 24.9% of TFC, compared to the IEA average of 36%. The main industry subsectors are chemical and petrochemical (19% of industry TFC in 2021), non-ferrous metals (19%), non-metallic minerals (19%), food and tobacco (14%), agriculture/forestry (9%), and construction (7%). Because of the lower role of heavy industry, the Greek industry sector has a relatively higher share of electricity in TFC (33% in 2021) than the IEA average (23%).

From 2005 to 2021, the Greek electricity generation mix underwent a major transformation, with the share of lignite-fired generation falling from 60% to 10%. The decline in lignite-fired generation has been offset mainly by increased gas-fired generation, which grew from 14% to 41% of generation, along with growth in wind (2% to 20%) and solar PV (0.02% to 10%). Hydro generation and electricity imports play notable but highly variable roles, with hydro ranging from a minimum of 4.1% of generation in 2007 to a maximum of 13% in 2010 and imports ranging from a minimum of 2.9% in 2012 to a maximum of 20% in 2019. Greece continues to rely on oil for a notable share of its generation, 7.4% in 2021, compared to the IEA average of 2% in 2020. Oil-fired generation is mainly used on Greek islands.

Key energy sector stakeholders

The **Ministry of Environment and Energy (MoEE)** is responsible for designing and implementing energy and climate policy. The MoEE also has responsibility for tracking progress on climate targets and reporting GHG emissions to the United Nations Framework Convention on Climate Change (UNFCCC). The **Ministry of Finance** is

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responsible for taxation and fiscal policy, including energy taxation. The **Ministry of Development and Investments** is responsible for investment policies in the energy sector and for financing energy innovation and research through national and EU resources.

Within the MoEE, the **General Secretariat for Energy and Mineral Resources** is responsible for implementing energy policy in sectors including electricity, oil, gas, renewables and energy efficiency and for disseminating energy statistics. The **Directorate of Energy Policies and Energy Efficiency** and the **Energy Inspectorate Units of the General Directorate of Inspectors and Auditors** are centrally involved in energy efficiency policy development and implementation. The **Centre for Renewable Energy Sources and Saving** is responsible for promoting renewable energy, rational use of energy and energy conservation. The Centre for Renewable Energy Sources and Saving is a public entity, supervised by the MoEE, but with financial and administrative independence. It implements innovative projects and promotes market penetration of new energy technologies for renewables and efficiency.

The **Regulatory Authority for Energy (RAE)** is a financially and administratively independent authority that oversees Greek energy markets. It has a consenting opinion on the National Gas and Electricity Grid Operation Code, the Power Exchanges Code, and the Gas and Power Distribution Network Operation Code. The RAE is also responsible for licensing energy market participants and overall energy market supervision. It plays a decisive role in market reforms and needs to ensure that the behaviour of the various system operators and market participants complies with EU regulations.

The **Hellenic Competition Commission** works to ensure market competition in Greece, including in the energy sector. It can make inquiries relating to market power or market abuse and acts as an advisory body to the government. It is overseen by the Ministry of Finance but is financially and operationally independent.

The **Hellenic Republic Asset Development Fund** is a state-controlled entity that manages the privatisation of state-controlled assets. Under the terms of the EU bail outs received from 2010 to 2019, Greece is required to privatise a wide range of state-controlled companies and assets, many of which play key roles in the energy sector. The Hellenic Republic Asset Development Fund is responsible for meeting revenue targets from the sale and leasing of state-controlled assets. The revenues from these activities are used mainly to pay off debt resulting from the bail outs, with some revenues supporting new investments in Greece.

The **Public Power Corporation S.A. (PPC)** is the historic incumbent electricity company. PPC owns the largest share of installed generation capacity, including most lignite-fired generation and associated mines, and all large-scale hydro generation. The PPC is the largest electricity supplier at the wholesale and retail level. In November 2021, the Greek state reduced its ownership share in PPC from 51% to 34% (PPC, 2022).

The **Independent Power Transmission Operator S.A. (IPTO)** is the Greek electricity transmission system operator (TSO), responsible for the operation, maintenance and development of the electricity transmission system and cross-border interconnections. IPTO is owned for 76% by the Greek state and 24% by the Chinese company State Grid (ADMIE Holding, 2022).

The **Hellenic Electricity Distribution Network Operator S.A. (HEDNO)** is the Greek electricity distribution system operator (DSO). It operates, maintains and develops the

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electricity distribution systems in mainland Greece and in the interconnected islands, and manages the electricity markets and distribution grids of non-interconnected islands. HEDNO is owned 51% by PPC and 49% by the Australian private company Macquarie Asset Management (HEDNO S.A., 2022).

The **Hellenic Gas Transmission System Operator S.A. (DESFA)** owns and operates the high-pressure gas transmission network and Greece's only LNG terminal. DESFA is owned 34% by the Greek state and 66% by SENFLUGA, a partnership owned by the Spanish and Belgian gas TSOs. **DEPA Infrastructure S.A.** owns three gas DSOs that serve most gas consumers in Greece (EDA Attikis, EDA Thess and DEDA). DEPA Infrastructure, formerly part of the incumbent state-owned gas company, is 100% owned by the private Italian company Italgas (Italgas, 2021). A new DSO, the private company HENGAS, was issued a licence by the RAE in 2020 to develop new distribution gas networks in nine areas of Greece (HENGAS, 2022).

The **Operator of Renewable Energy Sources and Guarantees of Origin (DAPEEP S.A.)** manages the subsidy schemes for renewable energy and high-efficiency co-generation and the auctioning of EU Emissions Trading System (ETS) allowances. It also acts as the aggregator of last resort for renewable energy producers.

The **Hellenic Petroleum S.A. (HELPE)** is the country's leading oil importer, refiner (65% market share), and retailer (over 30% market share). HELPE is owned by the Paneuropean Oil and Industrial Holdings S.A. (47%), the Greek state (35.5%), and institutional (8.5%) and private (9%) investors.

The **Hellenic Hydrocarbons Resources Management S.A. (HHRM)** is a 100% state-owned company responsible for managing exploration and production concessions for domestic oil and gas and for overseeing offshore safety of oil and gas operations. The HHRM's mandate was expanded in 2022 to cover licensing and monitoring of carbon capture and storage projects (HEREMA, 2022).

Energy and climate policies and targets

Greece's energy and climate policies are centred on transitioning to a net zero emissions energy system by 2050 while ensuring energy security, improving economic competitiveness and protecting vulnerable consumers. The NECP is the key document defining energy and climate policies through 2030. It sets national climate and energy targets and defines the measures to support the achievement of these targets. Energy and climate policies for the transport sector are also given in the National Transport Plan of Greece, adopted in June 2019, which defines the transport sector's development strategy from 2017 to 2037 (see Chapter 3).

Greece's energy policy focuses on increasing the use of renewable energy, especially for electricity generation (see Chapter 4), while increasing the share of energy demand covered by electricity, especially for transport and heating and cooling (see Chapters 3 and 6). Reducing the carbon intensity of electricity generation is also supported by a legal requirement to phase out lignite-fired generation by 2028. The government also aims to increase energy efficiency in all sectors (see Chapter 3) and to promote innovative energy technologies that support Greece's energy transition and economic growth (see Chapter 5). Greece aims to reduce oil demand, especially from transport, buildings and

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electricity generation on the islands, while maintaining the security of oil supply (see Chapter 8). Key policy documents (most of which were approved before 2021) give natural gas a major role in reducing lignite-fired generation and oil demand from building heating and industry. Following the Russian invasion of Ukraine and the sustained increase in gas prices, the government is re-evaluating the role of gas in the Greek energy system (see Chapter 7).

The government estimates that achieving the 2030 NECP targets will require investments totalling EUR 43.8 billion from 2021 to 2030. The European Commission's review of the NECP notes that while overall investment figures are given per policy area, the split between public and private funding is not specified, and the NECP lacks an analysis of the gap between investment needs and available sources of financing.

Under national laws and EU directives, Greece has numerous energy and climate targets (Table 1.1). GHG emissions from Greece's energy-intensive industry and large-scale electricity generation are regulated under the ETS. Greece's NECP, adopted in 2019, defines 2030 targets for non-ETS GHG emissions, renewable energy, energy efficiency and cross-border electricity interconnections. The National Climate Law, adopted in May 2022, sets targets to phase out lignite-fired electricity generation by 2028 and to reduce total GHG emissions by 55% by 2030, by 80% by 2040 and to achieve net zero emissions by 2050.

Greece achieved most of its 2020 energy and climate targets. However, a significant share of the reduction in GHG emissions and energy demand was caused by Greece's prolonged economic contraction following the 2008 crisis and by the Covid-19 pandemic. Greece has reduced the carbon intensity of its energy supply and economy, but an increase in demand following the lifting of pandemic restrictions is already leading to an increase in GHG emissions.

Table 1.1 Greece's 2020 and 2030 energy sector targets and status

Target	Metric	Status (2021)	2020 targets	2030 targets
Total GHG emissions	**CO_2-eq emissions versus 2005**	-38% (2020)	No target	-55%
Non-ETS GHG emissions	**CO_2-eq emissions versus 2005**	-28% (2020)	-4%	-16%
Energy efficiency (PJ)	**Primary energy consumption**	851	1 034	858
	Final energy consumption	637	770	690
Renewable energy share	**Gross final energy consumption**	22%	19.7%	35%
	Electricity	36%	29.2%	61%
	Heating and cooling	32%	30.6%	42.5%
	Transport	5.3%	6.6%	19%
Cross-border electricity interconnection		9.3% (2019)	10%	15%

The European Commission's official review of Greece's NECP noted that if Greece implements all its NECP measures, it will achieve an emissions reduction of 33% versus 2005, well beyond its 2030 target and the contribution needed to meet the EU-wide target. The review indicated that the 2030 target for renewables in gross final energy consumption exceeds the needed contribution to the EU-wide target. However, the European

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Commission also noted that the 2030 target for primary energy consumption was of modest ambition, and the 2030 target for final energy consumption of low ambition (EC, 2020).

In December 2020, the 2030 EU-wide GHG emissions reduction target was increased from 40% to 55%. To support the increased target and the REPowerEU efforts to end reliance on Russian energy, the European Union is updating numerous policies through the Fit-for-55 package, which will likely include higher targets for renewables and energy efficiency. Greece has started updating its NECP to reflect the increased EU climate and energy security ambition.

All EU member states are required to develop a National Long-term Strategy that details pathways and measures supporting EU-wide carbon neutrality by 2050. Greece's long-term strategy, adopted in 2019, presents four pathways to carbon neutrality, with modelling results showing GHG emissions reductions of 85-95% by 2050 compared with 1990. The National Climate Law, adopted in May 2022, strengthens Greece's long-term climate ambition with a target for net zero emissions by 2050 (see Chapter 2).

To ensure the efficient and effective functioning of its electricity market, Greece finalised major reforms in 2020 to introduce three wholesale electricity spot markets (day-ahead, intraday and balancing) and a derivatives market. Greece has also completed several reforms to support full integration in the European common electricity market, including joining the intraday European market coupling in December 2022 and opening its market to demand response in September 2022. Greece's gas market has also undergone major changes in recent years, with the opening of a natural gas spot market in March 2022 as a key achievement.

Covid-19 response

In response to the Covid-19 pandemic, the European Union established the Recovery and Resilience Facility, which provides EUR 724 billion through 2026 to support recovery and resilience plans developed by each EU member state. The plans detail projects and reforms to address the impacts of Covid-19, including impacts on the energy sector. Greece was among the first EU member states to submit a plan in April 2021. The European Commission approved the plan in July 2021, authorising EUR 30.5 billion in funding (EUR 17.8 billion in grants and EUR 12.7 billion in loans). The plan (Greece 2.0) is one of the largest funding requests to the Recovery and Resilience Facility and is equivalent to 16.7% of Greece's 2019 GDP. The plan dedicates 37.5% of funding to climate objectives and 23.3% to digital transition and includes numerous projects targeting the energy sector (European Parliament, 2022).

The plan funds energy efficiency subsidies for residential buildings (EUR 1.1 billion), businesses (EUR 0.45 billion) and the public sector (EUR 0.2 billion). In the electricity sector, there is funding to deploy 1.4 GW of electricity storage (EUR 0.45 billion), interconnect the islands (EUR 0.2 billion) and upgrade electricity distribution networks (EUR 0.1 billion). The plan also includes EUR 0.2 billion to instal 8 656 publicly accessible EV charging points, deploy 220 electric buses and replace older taxis with EVs. The plan further includes EUR 0.3 billion for energy RD&D relating to EVs and the development of Greece's first CO_2 storage facility. The plan also supports the implementation of a variety

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of energy sector reforms, including improvements to the main financing mechanism for renewables and co-generation and to licensing and spatial planning for renewables (Greece, Greece 2.0, 2022a).

The pandemic caused notable supply chain disruptions and reduced the availability of workers, delaying many renewable energy projects and creating risks that licenses, grid connection offers and eligibility for subsidies would expire before projects could meet needed milestones. In March 2020, the government granted four- to six-month extensions to comply with a variety of project requirements to help project developers cope with pandemic disruptions. In October 2020, Greece announced EUR 450 million in support to companies in sectors particularly affected by pandemic confinement measures, including energy, transport, tourism and construction. The support is provided as subsidised loans for companies with up to 3 000 employees.

Addressing energy poverty and high energy prices

Greece's NECP notes that energy poverty has been increasing and that reducing it is an important policy priority; the objective is to reduce it by at least 50% by 2025 and bring it below the EU average by 2030. The government estimates that in 2021, 17.5% of the total population and 36.7% of economically vulnerable consumers were unable to adequately heat their homes; these figures are higher than the 8% average for the European Union.

The social tariff (established in 2010) provides discounted electricity rates to several categories of economically or socially vulnerable residential consumers. The discounted rates are set by the government and vary depending on the category of consumer and their level of electricity demand. In 2022, the rates were 0-70 euros per megawatt hour (EUR/MWh) for four months of demand up to 800 kilowatt hours (kWh), 40-80 EUR/MWh for four months of demand from 0.8 MWh to 1.5-1.7 MWh, and 95 EUR/MWh for four months of demand over 1.5-2 MWh (with the upper limits depending on the type of consumer). These are notable reductions compared to the average retail price of around 240 EUR/MWh in 2021 (Protergia, 2022). The social tariff is financed mainly through the public service obligation fee charged to all electricity consumers that do not qualify for the social tariff. All electricity suppliers are obliged to offer the social tariff to qualifying consumers. The government estimates that in 2019, 500 000-550 000 households benefited from the social tariff.

In September 2021, Greece released an Action Plan to Combat Energy Poverty, which gives a quantitative definition of energy poverty and defines a broad strategy backed by specific measures to reduce energy poverty. The plans include measures to raise consumers' awareness of existing programmes and indicate that improving building energy efficiency is key to reducing energy poverty (Greece, Ministry of Environment and Energy, 2021).

Starting in late 2021, global energy prices began to increase rapidly, especially in Europe. Price spikes and high volatility persisted into 2022, driven mainly by the impacts of the Russian invasion of Ukraine. In March 2022, the Greek wholesale electricity spot price reached a record high of 427 EUR/MWh; in Q1 2022, the spot price averaged 236 EUR/MWh, compared to just 54 EUR/MWh in Q1 2021 (Tsarikas, 2022).

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Greece has taken numerous steps to limit the impact of high energy prices, especially for vulnerable consumers. The Greek efforts include expanding existing measures targeting energy poverty and introducing broader measures to reduce energy prices for most consumers. From September 2021 to November 2022, Greece dedicated EUR 9 billion to energy subsidies and other measures to help consumers pay utility bills. Most of this support is delivered through the Energy Transition Fund, established in 2021 to fund a variety of subsidies for electricity, natural gas, heating oil and transportation fuels to combat energy poverty and reduce the impact of high energy prices.

The Energy Transition Fund is financed via several sources. Since 2021, most ETS allowance revenues (around 75%) have been directed to the Energy Transition Fund. The fund also receives revenue from a one-time fee on electricity generator profits and revenues over the wholesale electricity price caps.

The heating oil allowance (established in 2019) provides grants to vulnerable consumers to reduce the cost of oil-based heating. In 2021, the requirements were relaxed to increase the number of consumers, with funding provided by the Energy Transition Fund. The allowance is a grant of EUR 100-750 per year for households with an annual income between EUR 14 000 and EUR 29 000 and a property value between EUR 180 000 and EUR 250 000. In 2021, around 1 million households received a heating oil allowance (up from 700 000 in 2020) at a cost of EUR 168 million (up from EUR 84 million in 2020) (Athens News, 2021).

In April 2022, the government launched an online platform providing direct payments to consumers to offset the high cost of road transportation fuels. The transport fuel subsidy is 0.15-0.2 EUR/litre for up to 60 litres of fuel per month and is available to consumers with an annual income below EUR 30 000.

In September 2021, the government established a one-time fee on profits earned by generators in Greece's wholesale electricity market from 1 October 2021 to 30 June 2022. The revenue collected via the fee was directed to the Energy Transition Fund. The total revenue from the one-time windfall profit fee is around EUR 500 million. In July 2022, the government introduced wholesale electricity market price caps. The price caps for generation from natural gas and lignite are based on fuel costs and ETS allowance prices and are adjusted on a monthly basis. In December 2022, the price cap was 240 EUR/MWh for gas-fired generation and 200 EUR/MWh for lignite-fired generation. The price caps for large hydropower (110 EUR/MWh) and other renewables (85 EUR/MWh) are fixed. Any revenue received above these caps is used to reduce consumer energy bills through the Energy Transition Fund.

In October 2022, the government updated the payment scheme for reducing consumer electricity bills to a three-bracket system with higher subsidies for lower demand and discounts to reward energy savings. The new subsidy is 436 EUR/MWh for consumers with demand from 0 to 500 kWh/month. For consumers with a demand of 501-1 000 kWh/month, the subsidy is 386 EUR/MWh but can be increased to 436 EUR/MWh if demand is reduced by at least 15% compared to the previous year. For consumers with demand above 1 001 kWh/month (less than 2% of households), the subsidy is 336 EUR/MWh but can be increased to 386 EUR/MWh if demand is reduced by at least 15% compared to the previous year. For businesses with demand above 2 000 kWh, the subsidy is 398 EUR/MWh. For consumers receiving the social tariff, the

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subsidy is 485 EUR/MWh regardless of the level of demand. Farmers receive a subsidy of 436 EUR/MWh. The government estimates these subsidies will cost around EUR 1.1 billion.

Starting in October 2022, gas-fired generation is charged a fee of 10 EUR/MWh on gas demand to fund reductions in electricity bills and investments to reduce reliance on Russian gas imports; at the same time, the government announced that subsidies for natural gas demand will be continued at 90 EUR/MWh for households and 90 EUR/MWh for businesses (Business Daily, 2022).

Reducing dependence on Russian fossil fuels

Greece has notable dependence on fossil fuel imports from Russia. In 2021, Russia accounted for 96% of hard coal imports, 41% of natural gas imports and 21% of crude oil imports and a small share of oil products imports. Hard coal imports are used mainly in industry, primarily for steel production. Gas-fired generation plays a key role in the Greek electricity system, and gas is also important for building heating and industry.

In January 2022, just prior to the Russian invasion of Ukraine, DEPA Commercial (one of Greece's main wholesale gas suppliers) signed a contract with Russia's Gazprom for 2 billion cubic metres (bcm) of gas per year gas until 2026 (Reuters, 2022). In 2021, Greece's total gas demand was 6.4 bcm. Greece is taking strong steps to decrease national and EU dependence on Russian gas (see Chapters 7 and 8).

Greece also supports the EU bans on imports of Russian coal and oil. In March 2022, the EU imposed sanctions banning all imports of Russian coal, which came into full effect in August 2022. In June 2022, the EU imposed sanctions banning seaborne imports of Russian crude oil starting on 5 December 2022 and Russian petroleum product imports starting on 5 February 2023. Greece receives all of its crude oil imports and most of its oil products imports via ship.

Shortly following the Russian invasion of Ukraine, Greece announced plans to boost import capacity at its LNG import terminal. A new floating storage unit at the LNG terminal started operations in August 2022, and DESFA indicates that LNG cargoes have doubled year-on-year and that imports from Russia have dropped from 40% to less than 20% of Greece's gas supply. Bulgaria has also been importing LNG through the terminal after being cut off from Russian supplies in April 2022. The Greek government indicated that thanks to increased LNG capacity and deliveries, gas exports to Bulgaria increased from 0.7 bcm in 2021 to 2 bcm through September 2022 (Koutantou, 2022).

In September 2022, DEPA Commercial reached an agreement with TotalEnergies of France to secure natural gas supplies for Greece in the event that imports from Russia are disrupted. The deal allows deliveries of two LNG cargoes through March 2023, which the government estimates could substitute almost 100% of Greece's remaining gas imports from Russia (Ekathimerini, 2022). Construction of a new floating LNG terminal started in May 2022; it should be operational by the end of 2023 and would almost double Greece's LNG import capacity. Additional LNG terminal projects are under consideration.

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Greece has announced that it will take steps to accelerate oil and gas exploration to reduce reliance on Russian imports. The HHRM wants to conclude a first round of seismic surveys in 2023 to identify gas fields in one onshore and five offshore areas in western Greece and off the island of Crete. Energean, currently the only oil producer in Greece, aims to carry out test drilling at an onshore block in the west of the country, the first test drilling in Greece in 22 years. The Greek Prime Minister said the country aspires to become a significant gas producer and a hub for storage and transfers to the rest of Europe (Koutantou and Maltezou, 2022).

Prior to the Russian invasion of Ukraine, the PPC was planning to replace lignite-fired generation with gas-fired generation by 2023. In June 2022, the PPC announced that the phase-out of lignite-fired generation was being extended to 2028 and increased extraction of lignite in 2022 from 10 million tonnes (Mt) to 15 Mt, with the additional lignite to serve as a security reserve in case of disruptions in the gas supply. The PPC has also accelerated its investment in renewable generation.

In May 2022, the European Commission introduced the REPowerEU plan, which proposes numerous measures to end EU reliance on Russian energy while supporting the energy transition. REPowerEU will provide EUR 225 billion in grant funding to support these efforts. In October 2022, the Greek Ministry of Finance announced that it expected to receive EUR 8.7 billion from the REPowerEU funds, which will be directed to existing projects and reforms defined in Greece's recovery and resilience plan (Energypress, 2022).

Under the REPowerEU plan, the European Union adopted a natural gas storage obligation requiring that EU gas storage facilities be at least 80% full by 1 November 2022 and 90% full by 1 November in subsequent years. Member states without large-scale storage facilities must store gas equal to at least 15% of their annual gas demand by 1 November 2022. Greece has no large-scale gas storage and intends to use gas stored in Italy and at a new floating storage unit at its LNG terminal to meet the EU gas storage requirement.

The IEA is working with the European Commission to support EU member states with implementing measures that will result in sustained reductions in their dependence on Russian fossil fuels. Greece is one of 17 EU member states that have requested assistance, specifically through a technical support project. This project aims to increase LNG supply and diversify pipeline imports of gas, increase the production of biomethane, accelerate the roll-out of renewable hydrogen and other suitable forms of fossil-free hydrogen, accelerate the roll-out of rooftop solar and heat pumps, implement additional demand-side and energy efficiency measures, and achieve faster permitting of renewable energy projects.

Energy taxation

The government aims for energy taxation to drive the energy transition. Greece's effective tax rates on CO_2 emissions from energy use are high compared to other OECD countries. However, tax rates vary across fuels and uses, as well as tax concessions, and provide inconsistent carbon price signals that are not well aligned with Greece's climate goals (OECD and IEA, 2021). Excise duties are levied on most energy products (Table 1.2). There is a 24% value-added tax (VAT) for oil products. A reduced VAT of 6% is applied to electricity and natural gas. Greece does not have a national carbon tax. Energy-intensive

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industrial facilities and large electricity plants are required to purchase ETS allowances based on their GHG emissions, with these costs passed on to final consumers.

Table 1.2 Excise duty by fuel excluding value-added tax in Greece, 2022

	Sector/end use	Value	Unit	EUR/GJ*
Heavy fuel oil	Heating	38	EUR/tonne	0.93
Light fuel oil	Heating	0.28	EUR/litre	7.29
Diesel	Automotive/heating	0.41	EUR/litre	11.20
	Winter heating**	0.28	EUR/litre	7.65
Gasoline	Automotive	0.7	EUR/litre	21.11
LPG	Automotive	430	EUR/tonne	9.35
	Heating	60	EUR/tonne	1.30
Natural gas	Electricity generation	10	EUR/MWh	
	Households	1.1	EUR/MWh	0.31
	Industry	0.4	EUR/MWh	0.11
Coal	Heating	0.3	EUR/GJ	0.30
Electricity	Households	2.2	EUR/MWh	0.61
	Industry (< 10 GWh)	5	EUR/MWh	1.39
	Industry (> 10 GWh)	2	EUR/MWh	0.56

* Estimate based on: heavy fuel oil (40.68 GJ/tonne), light fuel oil (0.038 GJ/L), diesel (0.037 GJ/L), gasoline (0.033 GJ/L), LPG (46.15 GJ/tonne).

** Diesel used for heating between 15 October and 30 April is subject to a reduced excise duty.

Notes: LPG = liquified petroleum gas; GWh = gigawatt hour; MWh = megawatt hour; GJ = gigajoule.

Natural gas for transportation; coal used for electricity generation, mineralogical and metallurgical processes and chemical reduction; oil products used for domestic marine shipping, ferries and fishing and for domestic aviation; and biomass used for electricity or heating are all exempt from excise duties.

Electricity consumers have to pay a fee that finances the public service obligations of electricity suppliers. These include the obligations to supply residents of the non-interconnected islands electricity at the same prices as in the mainland, despite higher generation costs; to provide electricity to economically and socially vulnerable consumers at a discounted social tariff; and to provide discounted electricity to legal entities, church institutions and non-profit organisations providing social welfare services. Electricity bills are used to collect a national radio and television fee (3.00 EUR/month) and municipal and real estate taxes. The numerous fees and charges applied to electricity create a complex bill that makes it difficult to determine how electricity consumption affects the total amount charged and reduces the incentive to save energy.

Electricity consumers also pay a Special Duty of Greenhouse Gas Emissions Reduction (ETMEAR) to fund subsidies for renewable electricity and high-efficiency co-generation projects. The RAE has the authority to set the ETMEAR rate; however, a ministerial decree temporarily moved this authority to the MoEE for 2019 and 2020. In 2019, the MoEE reduced the duty from 23 EUR/MWh to 17 EUR/MWh through 2028. Also in 2019, the ETMEAR rate was set below 17 EUR/MWh for agriculture, lignite mines, railroads, businesses and energy-intensive industry, with the lowest rate, for energy-intensive industry, set at 2.55 EUR/MWh.

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Lignite-fired generation owned by PPC is subject to a special lignite fee of 2 EUR/MWh based on net electricity generation. PPC is also charged a special tax equal to 0.5% of its annual turnover (OECD, 2022). Revenues from these taxes are used to support the communities impacted by the phase-out of lignite-fired generation and associated mining.

A supply security levy is charged to importers of crude oil and oil products destined for domestic consumption or refineries. These levies are calculated as 1.2% of the refinery price for the relevant crude or product and finance a fund used to maintain Greece's strategic oil reserves required under agreements with the IEA and the European Union (see Chapter 8). A supply security levy is also charged to natural gas consumers, with the rates calculated by the RAE. These levies are used to finance a security of supply account maintained by DESFA. This account covers costs related to security of supply, mainly payments to large gas consumers (gas-fired power plants and industry) for voluntary demand reductions undertaken when there are gas supply concerns (see Chapter 7).

Companies supplying natural gas, electricity and liquid fuels are obliged to collect a special duty from all consumers equal to 5% of the amount billed for each fuel (up to 0.5 EUR/MWh for electricity). The special duty is not subject to VAT. It is paid to the Greek Customs Authority and is incorporated into the state budget.

Fossil fuel subsidies

As an EU member state, Greece has committed to eliminate fossil fuel subsidies. However, the OECD estimates that in 2020, Greece provided over EUR 1.9 billion in fossil fuel subsidies, with 56% directed to households and 44% to companies. Most fossil fuel subsidies are provided as tax expenditures (foregone revenue), including EUR 0.54 billion in post-retirement benefits for PPC pensioners and employees and EUR 0.19 billion in reduced excise taxes on diesel used for heating. The largest direct transfers supporting fossil fuel use include EUR 0.4 billion in subsidies to oil-fired electricity generation on non-interconnected islands, EUR 0.31 billion in capacity payments to coal- and gas-fired generation, and EUR 0.17 billion for heating allowances for households (OECD, 2022).

From 2015 to 2020, fossil fuel subsidies decreased by 14% because of reductions in direct transfers supporting oil-fired electricity generation on non-interconnected islands and lower spending on heating allowances. Although decreasing, fossil fuel subsidies were still equivalent to more than one-quarter of energy tax revenue, among the highest share in the OECD.

Under EU regulations, all NECPs must include a detailed list of energy subsidies. The European Commission's review of the Greek NECP noted that this list is missing and that while the intention to reduce or phase out fossil fuel subsidies is expressed in the NECP, it does not include any specific measures to achieve this goal. In response to increasing energy prices in 2021 and 2022, Greece has introduced new measures or significantly expanded existing ones that support the consumption of heating oil, natural gas, diesel and gasoline.

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Assessment

The government's energy and climate policies are centred on achieving a 55% GHG emissions reduction by 2030 and net zero emissions by 2050 while ensuring energy security, improving economic competitiveness and protecting vulnerable consumers. The energy and climate policies are embedded in ambitious plans and laws. The NECP includes 2030 targets and supporting measures to put the country on a path to net zero emissions in 2050. The government estimates that achieving the 2030 NECP targets will require investments totalling EUR 43.8 billion from 2021 to 2030; funding for programmes supporting these targets largely comes from the European Union.

A key objective of the NECP is the phase-out of lignite-fired generation by 2028. Greece is working to ensure a just transition in the regions impacted by reduced lignite production, promoting economic diversification and helping local workforces acquire new skills. In 2022, Greece was awarded EUR 755 million from EU Just Transition Funds to support measures, including job replacement, recultivation of the lignite mines, ensuring alternative heating, installation of photovoltaic parks, and the development of natural gas and transportation networks.

The NECP lists other ambitious priorities, including the launch of the new electricity market model, promoting new technologies, accelerating electrical interconnection of the islands, strengthening energy interconnections with neighbouring countries, developing strategic energy storage projects, digitising energy networks and promoting electromobility. The NECP aims to increase generation from renewables (especially wind and solar PV) coupled with the electrification of energy demand (especially for building heating and cooling, and transport), improving energy efficiency in all sectors and greatly reducing reliance on lignite and oil. The NECP also gives a major role to natural gas, especially in electricity generation, buildings and industry, as a stepping stone towards greater integration of hydrogen into the country's energy balance.

Following the Russian invasion of Ukraine, a strong focus has been placed on reducing reliance on Russian energy imports, including natural gas, oil and hard coal. Plans to close most lignite-fired generation by 2023 were delayed to 2028, the deadline for the legally mandated phase-out. There are plans to expand exploration for domestic oil and gas, build more LNG terminals, identify alternative natural gas suppliers and expand renewable power generation. High natural gas prices, coupled with the country's efforts to diversify away from Russian energy imports, have raised questions about the central role gas is given in Greece's energy transition plans. The ongoing reliance on natural gas can also be seen as incompatible with the country's climate policy; investments in expanding the national gas network would be better directed to energy efficiency, renewables and energy storage. The government needs to rethink and rationalise the role of gas in its energy sector planning and policies to avoid stranded assets.

In the context of broader decarbonisation and energy diversification, the government and the energy industry have advocated their ambition to increase Greece's role in South East Europe. Key elements are the expansion of renewable generation to support electricity exports, the expansion of gas import, production and export infrastructure to act as a regional gas-trading hub. The government indicates that a South to North gas corridor could counter the historical reliance on an East to West corridor from Russia to Europe. The government also wants to play a key role in Europe's future hydrogen corridors.

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Greece has recently undertaken major reforms to ensure the efficient and effective functioning of its electricity and gas markets and to support full integration into the European common electricity market. Although promising, the results are too premature to assess the full outcomes of the market reforms. So far, competition remains limited in Greece's energy markets, with large incumbents in dominant positions. Both the government and the RAE need to continue their reform efforts to ensure a high level of market liquidity, transparency and competition.

The RAE plays a decisive role in market reforms and needs to ensure that the behaviour of the various system operators and market participants is compliant with the EU *acquis*. The RAE is significantly understaffed and has difficulties offering the competitive salaries needed to attract and retain senior experts. Figures for 2021 show that the RAE has a budgeted capacity of 211 permanent staff, while only 105 staff members (49 permanent and 56 non-permanent) were employed; a large share of the RAE workforce is relatively young with limited experience. The required expertise and capacity to carry out their tasks may not be available within the RAE, which may jeopardise the further strengthening of the market reforms.

There are also some concerns regarding the full independence of the RAE. Although the RAE maintains its own financial budget, there are significant legal restrictions, which do not allow it to make full use of its budget in an effective and independent manner. There are also instances in which the government has passed legislation or decrees that deal directly with areas which are supposed to be under the sole authority of the RAE. For example, the government temporarily moved the authority over setting the ETMEAR from the RAE to the MoEE in 2019 and 2020.

Greece's NECP notes that energy poverty is high, has been increasing and addressing it is an important policy priority. The NECP set an objective to reduce energy poverty by at least 50% by 2025 and to bring it below the EU average by 2030. Greece has adopted an Energy Poverty Action Plan with a road map and a list of measures. Currently, the main mechanism to address energy poverty is a social tariff that provides discounted electricity rates for vulnerable households. There is also an allowance for vulnerable households to reduce the cost of oil-based heating. In 2021, the requirements for the oil-heating allowance were relaxed to increase the number of consumers covered by the scheme. Such measures, however, are not sustainable in the long run.

While direct grants are understandable in an emergency situation like the current gas crisis, funding should also support measures that deliver long-term reductions in energy bills, for example, energy efficiency improvements, especially for vulnerable households. This would help to ensure that the Energy Transition Fund lives up to its name.

Energy taxation can serve as a well-suited instrument to influence and steer consumers' behaviour and decisions in a preferred direction. Although various taxation schemes are in place, these do not provide the consistent price signal that incentivises the energy transition. Examples are the lower taxation of diesel (compared to gasoline); existing exemptions from excise duties for domestic marine shipping, ferries, fishing and domestic aviation; and highly taxed electricity undermining efforts to drive electrification and notable fossil fuel subsidies (which totalled EUR 1.9 billion in 2020 and include direct payment to lower the cost of fossil fuels).

In September 2022, the government introduced a 10 EUR/MWh tax for gas used in gas-fired electricity generation. Revenue from the tax will go to the Energy Transition Fund

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to reduce consumer energy bills and will also support investments that help to end dependence on Russian gas. The government should consider eliminating the tax on gas used for electricity generation. The tax seems intended to fund a reduction in electricity bills, but it will most likely increase the cost of electricity, defeating the intended goal.

Recommendations

The government of Greece should:

- Strengthen efforts to reform the electricity and gas markets to ensure that consumers benefit from the advantages of efficient wholesale and retail markets.
- Establish a mechanism to co-ordinate electricity and gas infrastructure development plans to identify and address concerns on energy security, system stability, emissions reductions and stranded assets.
- Strengthen the expertise and capacity of the Regulatory Authority for Energy, as it will play a key role in the further opening of the electricity and gas markets, as well as monitoring market behaviour, designing and implementing new support schemes, and protecting end user interests while ensuring security of supply.
- Ensure transparent and stable legal and regulatory frameworks, which enable renewables and electricity infrastructure projects to be implemented within a reasonable time frame. Streamline the procedures for spatial planning and licences to facilitate the deployment of projects in a timely fashion.
- Ensure that measures to address energy poverty and high energy prices focus on delivering long-term reductions in energy bills, for example, through energy efficiency measures, and give priority to vulnerable households.
- Adjust taxes, market regulations and financial support measures so that energy prices drive behaviour and investment towards a just energy transition, increase system flexibility, and reduce the risk of stranded assets.

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2. Energy and climate change

Key data

GHG emissions with LULUCF (2020): 70.9 Mt CO_2-eq; -47% since 2005, -30% since 1990

GHG emissions without LULUCF (2020): 74.8 Mt CO_2-eq; -45% since 2005, -28% since 1990

Energy-related GHG emissions (2021):

GHG emissions from fuel combustion: 50.4 Mt CO_2-eq; -48% since 2005

GHG emissions by sector: electricity and heat generation 38%, transport 32%, buildings 11%, industry 19%

GHG intensity per GDP: 0.167 kg CO_2-eq/USD (IEA average in 2020: 0.188 kg CO_2/USD)

GHG intensity per capita: 4.655 t CO_2-eq/capita (IEA average in 2020: 7.97 t CO_2/capita)

Overview

Greece's climate policy is centred on transitioning to a net zero emissions energy system by 2050 while ensuring energy security, improving economic competitiveness and protecting vulnerable consumers. Greece's National Climate Law, adopted in May 2022, sets targets to reduce total GHG emissions (excluding land use, land-use change and forestry [LULUCF]) by 55% by 2030 and by 80% by 2040 (versus 2005), and to achieve net zero emissions by 2050. Greece also supports the achievement of targets to reduce EU-wide GHG emissions by 55% (versus 1990) and achieve net zero emissions by 2050. The NECP is the main document defining the mitigation measures to achieve Greece's 2030 emissions reduction target and put the country on a path to a net zero energy system. Greece's National Long-term Strategy details emissions reduction pathways that aim to support the EU-wide 2050 net zero emissions target.

From 2005 to 2020, Greece's total GHG emissions excluding LULUCF fell by 45%, from 136.4 million tonnes of carbon dioxide equivalent (Mt CO_2-eq) to 74.8 Mt CO_2-eq. This decrease was driven by lower economic activity resulting from the prolonged economic crisis and the Covid-19 pandemic, but also by a sharp reduction of the carbon intensity of electricity generation and building heating. Most GHG emissions are energy related (75% in 2020), followed by industrial process emissions (14%), agriculture (10%) and waste (7%). From 2005 to 2020, LULUCF consistently acted as an emissions sink, but the level of absorbed emissions has varied notably, from a minimum of 0.1 Mt CO_2-eq to a maximum of 4.0 Mt CO_2-eq. Greece is facing increased risks of droughts and wildfires that could notably reduce the LULUCF emissions sink or even result in LULUCF becoming a net emissions source.

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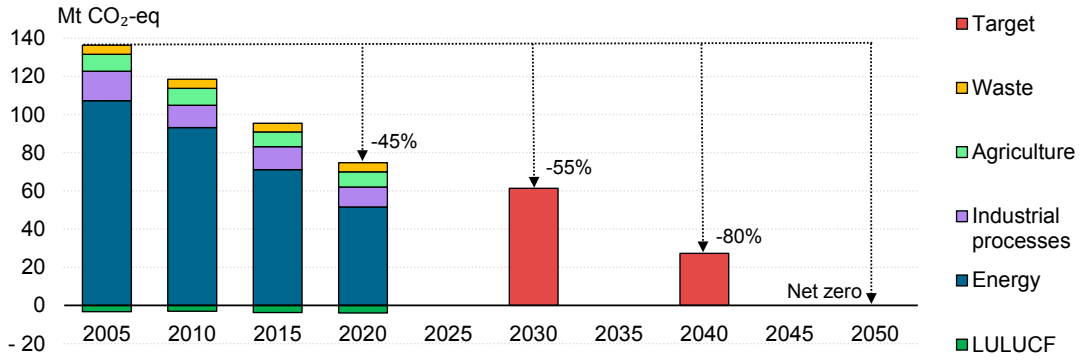
Figure 2.1 Greenhouse gas emissions by sector in Greece, 2005-2020 and targets



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Source: IEA based on data from UNFCCC (2022).

Energy-related greenhouse gas emissions

Greece's energy-related GHG emissions peaked in 2007 at 99 Mt CO_2-eq and have since decreased significantly to reach 49 Mt CO_2-eq in 2020 (Figure 2.2). This decrease was driven by lower economic activity resulting from the prolonged economic crisis and the Covid-19 pandemic but also by structural changes, including a sharp reduction in lignite-fired electricity generation and oil-fired building heating. The lifting of most pandemic-related restrictions and the reopening of Greece to tourism caused a slight rebound in energy-related emissions, which reached 50.4 Mt CO_2-eq in 2021. In 2021, electricity and heat generation accounted for 38% of energy-related emissions, followed by transport (32%), industry (19%) and buildings (11%). These shares reflect the relatively limited role of industry in Greece's economy; the continued reliance on oil-fuel transport; and the declining, but still relatively high, carbon intensity of electricity generation.

From 2005 to 2021, emissions from electricity and heat generation dropped from 47 Mt CO_2-eq to 19 Mt CO_2-eq as the share of lignite-fired generation dropped from 40% to 14%. The reduction in lignite-fired generation resulted in higher generation from natural gas, which grew from 5.4% to 24% of generation and increased renewable generation, which grew from 11% to 41% of generation. Transport emissions peaked in 2009 at 25.4 Mt CO_2-eq but decreased sharply to 16.9 Mt CO_2-eq in 2012, mainly because of Greece's economic crisis. Transport GHG emissions started increasing in 2013 and reached 18 Mt CO_2 in 2019. The Covid-19 pandemic caused transport GHG emissions to drop to 15.2 Mt CO_2-eq in 2020, but they rose again to 16 Mt CO_2-eq in 2021. From 2010 to 2020, the industry sector's GHG emissions experienced an overall decrease, from 11.6 Mt CO_2-eq to 9.4 Mt CO_2-eq. Most of this reduction occurred between 2010 and 2013, in line with the reduction in economic activity.

Building sector emissions are mainly driven by seasonal heating demand, as space heating accounts for most building energy demand (56% in 2020). Unusually cold temperatures caused building GHG emissions to peak in 2011 at 10.2 Mt CO_2-eq. Building emissions have also been falling because of a change in the fuel mix, mainly through a reduction in the use of oil for space heating, which dropped from 125 PJ in 2005 to 48 PJ in 2020.

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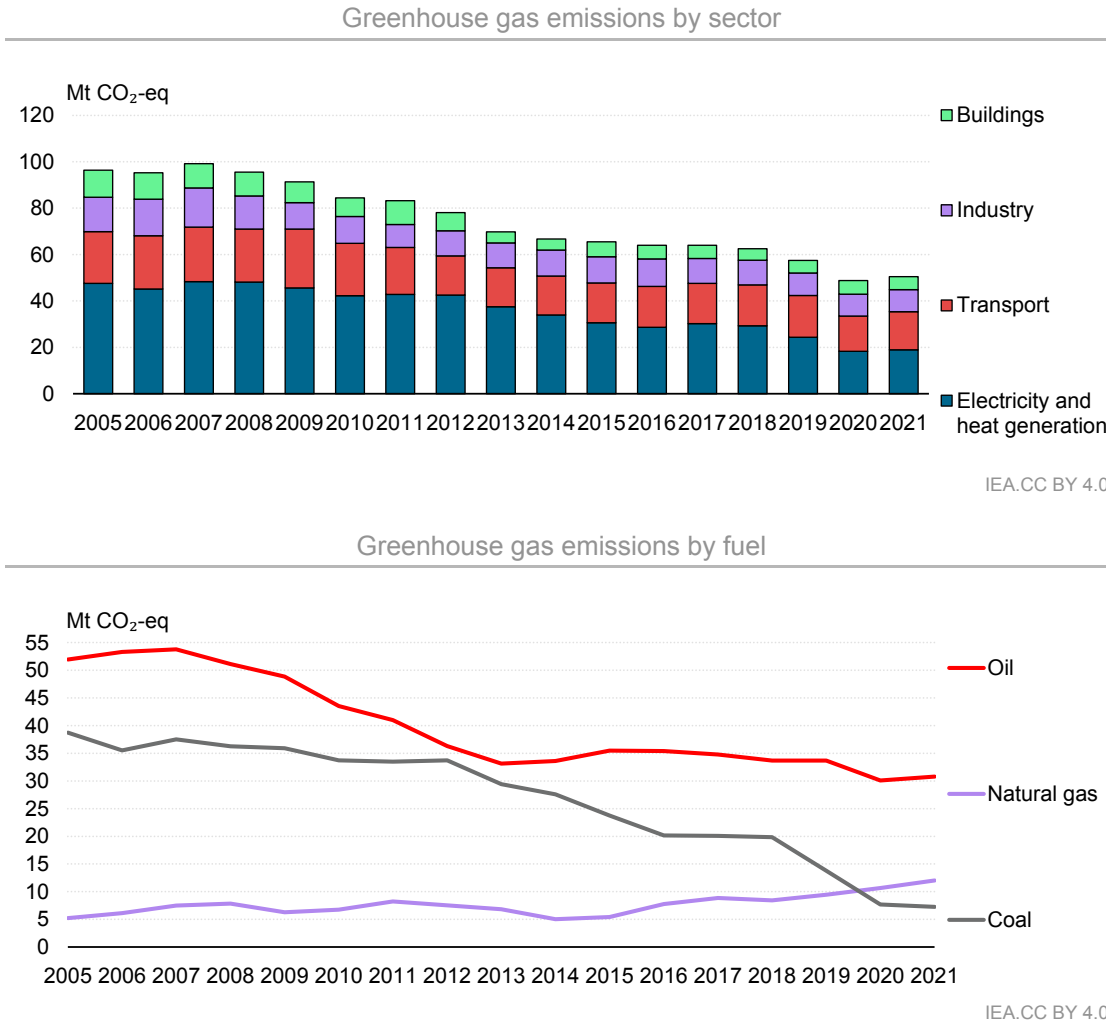
Figure 2.2 Energy-related greenhouse gas emissions by sector and fuel in Greece, 2005-2021



Source: IEA (2022a).

Greece's energy-related GHG emissions came mostly from oil (61% in 2021), followed by natural gas (24%) and coal (15%). Most coal-related emissions (89% in 2021) come from lignite-fired generation. From 2005 to 2013, emissions from oil dropped substantially from 52 Mt CO_2-eq to 33 Mt CO_2-eq, mainly because of a reduction in road transport related to Greece's prolonged crisis. From 2013 to 2019, oil-related GHG emissions were relatively stable. The pandemic resulted in a notable drop in transport energy demand, which reduced oil-related emissions down to a historic low of 30 Mt CO_2-eq.

From 2005 to 2021, coal-related GHG emissions dropped significantly, from 38.7 Mt CO_2-eq to 7.1 Mt CO_2-eq; most of this reduction came from the transition away from lignite-fired generation. Over the same period, emissions from natural gas grew from 5.2 Mt CO_2-eq to a record high of 12 Mt CO_2-eq. The increase in gas-related GHG emissions was driven mainly by the higher use of gas-fired generation (the main technology replacing lignite-fired generation) and, to a lesser extent, because of a switch from oil to natural gas in buildings and industry.

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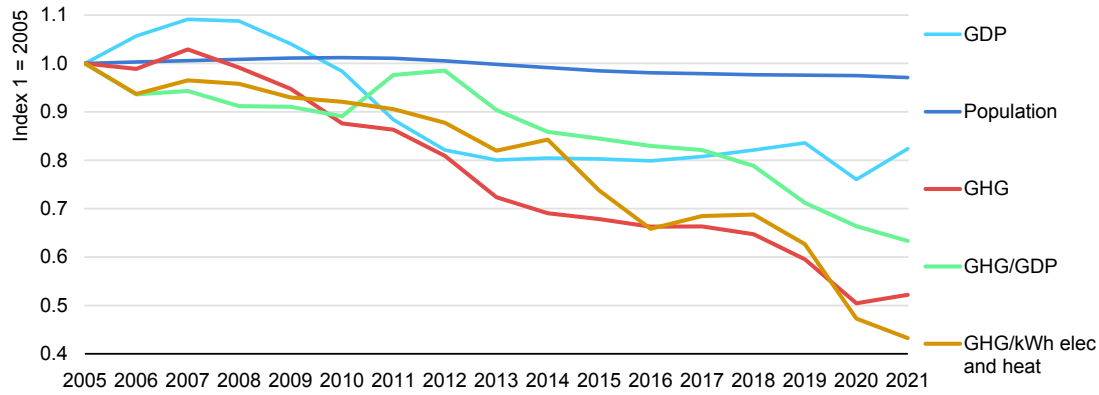
Emissions drivers and carbon intensity

The main drivers for GHG emissions reductions were declining GDP and a reduction in the carbon intensity of electricity and heat generation. (Figure 2.3). Greece's prolonged economic crisis reduced GDP by 27% from 2008 to 2013, with GDP growth only returning in 2017. The pandemic had a major impact on GDP, which fell by 14.8% in 2020, then again by 9.9% in 2021. However, emissions rebounded from 2020 despite the continuing decline in the carbon intensity of electricity and heat generation. From 2005 to 2021, Greece's carbon intensity of electricity generation dropped substantially, from 791.6 gramme CO_2/kWh to 342.4 g CO_2/kWh. This was the fifth-largest reduction in the carbon intensity of generation among IEA member countries over this period.

Figure 2.3 Energy-related greenhouse gas emissions and main drivers in Greece, 2005-2021



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Source: IEA (2022a).

Climate targets

Greece's National Climate Law, adopted in May 2022, sets targets to reduce total GHG emissions by 55% by 2030 and by 80% by 2040 (versus 2005) and to achieve net zero emissions by 2050. Greece's GHG emissions are also subject to targets and regulations under EU laws and directives. GHG emissions from Greece's large electricity plants, energy-intensive industrial facilities and commercial aviation inside Europe are regulated under the EU Emissions Trading System. The ETS sets annual caps on emissions and requires regulated facilities to acquire tradable allowances for their emissions. Greece's non-ETS emissions (transport, buildings, agriculture, waste and non-energy intensive industry) are subject to a 2020 target under the EU Effort Sharing Decision (ESD) and a 2030 target under the EU Effort Sharing Regulation (ESR). In combination, the ETS, ESD and ESR aim for a 20% reduction in EU-wide GHG emissions by 2020 and a 40% reduction by 2030 (both versus 1990 levels).

In 2020, 43% of Greece's GHG emissions were covered by the ETS and came primarily from electricity generation (63% of ETS emissions) and industry (36%). Greece had the third-largest decrease in ETS emissions, which fell by 56% from 2005 to 2020, thanks mainly to reduced lignite-fired generation (The Green Tank, 2021). In 2020, 57% of

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Greece's GHG emissions were from non-ETS sources. In 2019, the largest shares of non-ETS emissions came from transport (39%) and industry (19%).

Greece was required to reduce non-ETS emissions by 4% by 2020 versus 2005 levels. Greece achieved a 28% reduction in non-ETS emissions in 2020, greatly exceeding the ESD target. However, this resulted largely from the significant reduction in energy demand caused by the negative impacts of Greece's prolonged economic contraction and the pandemic. Without additional actions, improved economic performance will likely lead to notable increases in emissions.

Greece's NECP sets a target to reduce non-ETS GHG emissions by 16% by 2030 versus 2005 levels. This target is in line with the expected contribution to EU-wide emissions reductions expected under the ESR. Greece has already exceeded this target, meaning emissions are allowed to increase notably through 2030. However, the European Commission has noted that if Greece implements all the emissions reduction measures in its NECP, it would achieve an emissions reduction of -33% versus 2005, well beyond the 2030 target. The European Commission also indicated that the NECP does not include information on how Greece will achieve its commitment that LULUCF emissions will not exceed LULUCF removals.

The European Climate Law, which entered into force in July 2021, increased the EU-wide GHG emissions reduction targets to 55% by 2030 and net zero emissions by 2050. Under the Fit-for-55 package, the European Union is updating a wide range of energy- and climate-related regulations to address the increased ambition of the 55% target. This includes setting stronger targets for renewable energy, energy efficiency and notable updates to the ETS. Greece will likely have to increase its ambition on emissions reductions to support the EU-wide 55% target.

Climate policy and mitigation measures

Greece's climate policy is centred on transitioning to a net zero emissions energy system by 2050 while ensuring energy security, improving economic competitiveness and protecting vulnerable consumers. Greece's Climate Law sets a binding target for net zero GHG emissions by 2050, with intermediate targets for 2030 and 2040. The law requires that five-year carbon budgets for key sectors of the economy be in place by 2026. It also requires the development of progress indicators for relevant targets, progress assessments and target adjustment procedures. The law places an increased emphasis on climate adaptation to limit the impacts of climate change on the Greek economy, including the energy sector.

The NECP is the main document defining the mitigation measures to achieve the 2030 emissions reduction target and put Greece on a path to a net zero energy system. The National Transport Plan of Greece, which defines the transport sector development strategy from 2017 to 2037, also details mitigation measures to reduce transport sector emissions. Many of the measures with the greatest emissions reductions potentially relate mainly to increasing the deployment of renewable energy (see Chapter 4) and improving energy efficiency (see Chapter 3), with key measures aiming for emissions reductions totalling around 12 Mt CO_2-eq by 2025 and around 17 Mt CO_2-eq by 2030 (see Table 2.1).

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Table 2.1 Key mitigation measures and estimated emissions reductions in Greece

Mitigation action	Measures	Reduction (Mt CO_2-eq) 2025	2030
Increased renewables in electricity generation	• Support innovative renewable energy projects • Guarantee of origin for renewable electricity • Develop licensing and planning framework for offshore wind farms • Develop legislative and regulatory framework for energy storage • Provide financial support for energy communities • Reform of the electricity market regulatory framework to promote the participation of decentralised energy schemes • Develop demand-side management programmes • Develop a licensing framework and technical specifications for renewable district heating, biogas injection into the gas network and geothermal	8.3	11.8
Increased biofuels in transport	• Enhanced blending obligations with possible extension beyond road transport • Development of biofuels support schemes and special financing tools for advanced biofuels production • Pilot projects for gaseous fuels in the transport sector • Tax incentives for alternative fuels in transport	0.10	0.43
Energy efficiency in industry	• Financial and tax support for energy-saving technology investments • Financial support to energy efficiency programmes • Creation of industrial business zones • District heating at industrial business zones	0.76	1.28
Energy efficiency in buildings	• Establish a National Energy Efficiency Fund • Tax incentives for renewable heating and cooling • Energy saving contracting in the public sector • Financing programmes and tax incentives for renovation of public and private buildings • Improve regulatory framework and strengthen role of energy managers • Energy management systems in public buildings • Regulation promoting nearly-zero energy buildings • Financial programmes promoting energy efficiency agreements in the private sector • Expand gas network to reduce oil-fired heating	2.27	2.99
Electrification and energy efficiency in road transport	• 10% share of electric vehicles (EVs) in passenger cars by 2030 • Deployed needed EV charging • Financial support of EV adoption • Sustainable urban mobility plans • Relocate commercial transport operations • Incentives for energy-efficient vehicles • Limiting import of older used cars • Maximum age for all vehicle types • Vehicle taxation promoting new and clean vehicles	0.05	0.19
LULUCF	• Increase of managed forest land for bioenergy	0.13	0.3

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In 2019, Greece established an Inter-Ministerial Committee for Energy and Climate, which is responsible for developing a governance framework to ensure efficient co-ordination across the government on implementing the NECP measures, monitoring progress on the 2030 targets, and redesigning existing measures and designing new ones, as needed, to ensure the achievement of climate goals.

Phasing out lignite-fired generation is central to achieving Greece's 2030 climate targets. The National Climate Law requires the phase-out of all lignite-fired generation by 2028. Plans to phase out lignite have significantly accelerated in recent years, with indications that most lignite-fired generation could end by 2023. However, this accelerated timeline relied heavily on a transition to gas-fired generation. Following Russia's invasion of Ukraine, Greece indicated that while it is committed to the 2028 lignite phase-out, higher use of lignite may be needed in the short term to address energy security concerns relating to Russian gas imports, which covered around 41% of gas supply in 2021 (see Chapter 6).

The Climate Law also bans the installation of oil-fired heating from 2025 and requires that from 2030 heating contain at least 30% by volume of renewable liquid fuels. The government is also aiming to end the use of oil-fired electricity generation on islands through electricity interconnection to the main grid and/or deployment of renewable generation on the islands.

The NECP and other planning documents give natural gas a major role in reducing emissions, not just from lignite-fired generation but also through an expansion of the gas network to reduce oil demand from building heating and industry. As a result of the sharp and sustained increase in gas prices and the desire to reduce reliance on Russian energy, the government is re-evaluating the role of natural gas in the energy system and has taken steps to diversify gas supply and reduce gas demand through the accelerated deployment of renewables and energy efficiency measures. However, significant investments to expand the natural gas network are still planned, and the government has indicated that it wants Greece to become a regional gas-trading hub (see Chapter 7).

Greece is also looking at options to reduce GHG emissions from marine shipping, which plays a major role in its economy and is a significant source of emissions (3.4% of energy-related emissions in 2020). In 2018, the port of Killini demonstrated a project to allow docked ships to be connected to the electricity grid to allow their engines to be turned off while docked. In February 2022, the government held meetings to discuss the legal and regulatory changes needed to allow shore powering of docked ships.

Greece's National Long-term Strategy (adopted in 2019) details emissions reduction pathways that aim to support the EU-wide goal of net zero emissions by 2050. It presents four pathways supporting emissions reductions of 95% by 2050 compared with 1990 (for a 1.5°C target) or 85% (for a 20°C target). These pathways depend on a strong increase in renewable energy deployment and energy efficiency measures across all sectors and the use of hydrogen in hard-to-decarbonise sectors. The strategy estimates that achieving net zero emissions will require annual investments of EUR 38.1 billion to EUR 39.1 billion from 2031 to 2050 (Ricardo Energy & Environment, 2020).

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EU Emissions Trading System

GHG emissions from Greece's large electricity plants, energy-intensive industrial facilities and commercial aviation inside Europe are regulated under the ETS, the only carbon-pricing system used in Greece. In 2020, the ETS covered around 43% of Greece's total GHG emissions. Entities regulated by the ETS must have allowances for their emissions, with most allowances purchased through auctions. Revenues from the auctions are delivered to countries participating in the ETS based on the total value of allowances purchased by regulated entities operating inside their borders. EU rules require that funding equal to at least 50% of ETS allowance revenues delivered to each member state be spent to modernise the energy system and reduce GHG emissions. Greece has a law requiring 100% of ETS revenues to be spent on domestic climate change and energy projects.

ETS allowance prices were relatively stable from the start of the ETS in 2013 until 2017, at 4-8 EUR/t CO_2. As a result of ETS reforms and market factors, ETS prices began to increase in 2018, with a rapid increase starting in late 2020 when the price exceeded 30 EUR/t CO_2 for the first time. The ETS price has remained high since, reaching an all-time high over 105 EUR/t CO_2 in March 2023. The rapid increase in ETS prices resulted in strong growth of ETS revenues going to Greece. From 2013 to 2021, Greece's annual ETS revenue increased from EUR 148 million to EUR 458 million, with a peak annual revenue of EUR 523 million in 2018. In 2019, ETS revenues accounted for around 7% of total revenues from Greece's environmental taxation (EC, 2021).

As of 2021, Greece had received a total of EUR 2.82 billion in ETS revenues. ETS revenues had been a key source of funding for renewable energy programmes, but since 2021, there has been a major shift and the majority of ETS revenues now support programmes that aim to limit the impact of high energy prices.

Independent analysis indicates that from 2013 to 2020, most of Greece's ETS revenues (up to 78%) went to the Special Account for Renewable Energy Sources, the main source for funding subsidies for renewable energy and co-generation (see Chapter 4). The next highest share of ETS revenues (up to 17%) went to compensation of industrial companies at risk of carbon leakage (leaving Greece). This type of compensation is allowed under ETS rules; however, it is unclear if Greece requires the companies receiving the compensation to take any measure to reduce their climate impact. Smaller shares of annual ETS revenues (3-13%) have gone to programmes supporting the adoption of EVs and the implementation of energy efficiency in buildings and by small and medium-sized enterprises (SMEs). A small share of annual ETS revenues (1-6%) is the sole funding source for the National Fair Transition Fund, which finances projects for sustainable, low-carbon economic activities in regions of Greece impacted by the phase-out of lignite mining (Haase et al., 2022).

In 2021, Greece made major changes to how ETS revenues are allocated, shifting most ETS revenues from the Special Account for Renewable Energy Sources to the Energy Transition Fund, which provides direct payments to Greek consumers and companies to reduce the impact of high energy prices (see Chapter 1). Independent analysis indicates that most ETS revenues are now going to the Energy Transition Fund (74% in 2021 and 75% in 2022). This allocation does not meet the EU requirement that 50% of ETS revenues be spent to modernise the energy system and reduce GHG emissions.[33]

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The European Union is significantly updating and expanding the ETS to align it with the increased EU-wide 55% emissions reduction target. The proposed changes would have notable impacts in Greece. In particular, it is planned to expand the ETS to cover emissions for marine shipping, a major sector of the Greek economy.

Methane emissions

CO_2 is the main GHG in Greece (98.4% of emissions in 2021), followed by nitrous oxide (0.9%) and methane (0.7%). In 2021, methane emissions from the energy sector were 717 kilotonne carbon dioxide equivalent (kt CO_2-eq), the majority of which came from lignite mining (64%). Methane emissions from fuel combustion in transport and residential buildings were 232 kt CO_2-eq and 94 kt CO_2-eq, respectively. Methane emissions from the oil and gas sector (domestic oil and gas production and fugitive emissions from natural gas transmission and distribution) were 130 kt CO_2-eq.

From 2005 to 2020, Greece's methane emissions from the energy sector decreased by 64%, mainly because of reduced lignite mining. The planned phase-out of lignite-fired generation (and associated mining) by 2028 should drive a significant reduction in energy sector methane emissions. However, the NECP notes plans to expand the gas network, and following the Russian invasion of Ukraine, Greece has announced plans to increase domestic oil and gas production. Without any policy action, these plans would likely increase methane emissions from the oil and gas sectors.

Greece has not adopted national targets for reducing emissions; however, it has supported various international efforts to reduce methane emissions. At COP 26 in November 2021, Greece signed the Global Methane Pledge. Countries joining the pledge agreed to take voluntary actions to reduce global methane emissions by at least 30% by 2030 (versus 2020) and to move towards using best available methodologies to quantify their methane emissions (Global Methane Pledge, 2022).

Methane emissions in Greece will soon be regulated under new EU rules. The EU Methane Strategy (adopted in 2020) aims to reduce methane emissions by 35-37% by 2030 (versus 2005 levels) to support the EU target to reduce total GHG gases by 55% by 2030. Current EU policies are projected to reduce methane emissions by only 29% by 2030. In December 2021, the European Commission published the hydrogen and gas market decarbonisation package, including proposed regulations to reduce energy sector methane emissions (FSR, 2021).

Carbon capture, utilisation and storage

Greece does not have a national carbon capture, utilisation and storage (CCUS) strategy. The NECP includes several references to CCUS but does not define any specific projects, targets or support mechanisms. Greece has transposed the EU Directive on the Geological Storage of Carbon Dioxide to establish a regulatory and legal framework for CO_2 storage and has defined areas where CO_2 storage is allowed. The government indicates that the most promising sites for CO_2 storage are mature oil fields in the Southern Kavala region.

In 2021, Energean, the only company active in oil production in Greece, proposed the country's first CCS project. The project aims to develop the offshore Prinos field into a CO_2

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storage site with a capacity of around 50 Mt CO_2 and to build a hydrogen production facility based on natural gas with emissions stored in the Prinos field. The cost of the project has been estimated at EUR 500 million. The Greek recovery and resilience plan includes funding for the project. Energean indicates that the project will start operating in 2025; in early 2022, it announced progress on design work and the selection of a contractor to assess the storage potential of the Prinos basin (OE, 2022). The government has indicated that the project cannot support advanced oil recovery under EU funding rules.

Climate change impacts and adaptation

Several studies have been conducted to assess climate change impacts in Greece, including the IEA *Climate Resilience Policy Indicator* report published in June 2022 (IEA, 2022b). There is a general consensus that Greece will face increasing temperatures throughout the 21st century. The higher temperatures will likely drive changes in seasonal energy demand, with a strong increase in electricity demand in summer linked to higher demand for air conditioning and reduced demand for a variety of fuels linked to lower heating demand in the winter.

The likely increase in high temperatures poses risks to electricity security, as it will drive higher demand while simultaneously reducing the capacity of the electricity system to generate and supply electricity (reduced thermal generation output and lower transmission and distribution capacity). Various climate change impacts studies also show that precipitation is projected to decrease further, adding risks to the electricity system due to lower availability of hydropower and thermal generation. Lower precipitation, combined with higher temperatures, will considerably increase the risk of wildfires, which pose risks to energy assets.

In 2021, the government conducted an updated climate impact assessment that estimates variations in 22 climate parameters and indices for the periods 2031-2060 and 2071-2100, including variations in the number of days per year with high demand for heating (temperature less than 10°C) and cooling (temperature greater than 30°C). The projections are publicly available as GIS maps on the MoEE website and confirm the trends of higher temperatures and lower precipitation (Greece, Ministry of Environment and Energy, 2022). The Greek electricity transmission system operator has also used climate scenarios to estimate future peak demand.

Greece's National Adaptation Strategy (adopted in 2016) defines the goals, principles and priorities for climate adaptation and lists possible adaptation measures for all environmental and socio-economic sectors likely to be significantly affected by climate change. The strategy includes the energy sector as one of 15 priority areas and proposes actions to enhance its climate resilience, including the deployment of smart energy networks to enable demand side response, incorporating precautionary measures into energy infrastructure planning, and conducting vulnerability assessments for energy infrastructure. It also suggests measures to safeguard the energy system by protecting the water resources used for electricity generation and enabling the development of new technologies to increase overall energy system resilience.

The National Adaptation Strategy will be implemented through 13 regional adaptation action plans, which have been finalised and are expected to be endorsed in 2023. Each

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regional plan applies the overall goals of the national strategy based on regional circumstances, priorities and needs and includes concrete measures/actions per sector. For the energy sector, the regional plans foresee dedicated climate change vulnerability and impact assessments to identify climate vulnerability hotspots and actions to adapt energy infrastructure to climate impacts, including impacts from increased energy demand for cooling in the housing and tourism sectors.

The National Climate Law includes a number of measures for adapting to climate change, such as the establishment of a National Observatory for Climate Change Adaptation and the mandatory insurance of housing in highly vulnerable areas from 2025 onwards.

LIFE-IP AdaptInGR is an EU-funded project that aims to support the implementation of the National Adaptation Strategy and the 13 regional adaptation plans from 2016 to 2025 and the preparation of updated adaptation policies from 2026 onwards. The project has a budget of EUR 14.2 million, mostly from the European Union (EUR 8.3 million) but also from the national budget (EUR 2.4 million), partners (EUR 3.2 million) and private sector co-financers (EUR 0.3 million) (Adaptivgreece, 2022).

Assessment

Greece's total greenhouse gas emissions excluding LULUCF fell by 27.8% between 1990 and 2020 (30% with LULUCF), mainly because of a reduction in energy-related emissions, which account for 75% of total GHG emissions. From 2005 to 2020, Greece's energy-related GHG emissions decreased significantly, from 96.3 Mt CO_2-eq to 48.8 Mt CO_2-eq. This reduction was driven by the prolonged contraction of the economy; the Covid-19 pandemic; and a transition away from lignite-fired generation to generation from natural gas, wind and solar PV. With the easing of pandemic restrictions, emissions rebounded to 49.2 Mt CO_2-eq in 2021. The government needs to examine current and planned emissions reduction measures to ensure that the desired return to strong economic growth does not result in increased emissions.

Greece has a target to reduce non-ETS GHG emissions by 16% by 2030 versus 2005. Greece has already exceeded this target. Also, the European Commission, in its review of Greece's NECP, has noted that if Greece implements all the emissions reduction measures listed, it will achieve an emissions reduction of -33% versus 2005, well beyond the 2030 target. Adopting the European Commission's proposals supporting the achievement of the EU-wide 55% emissions reduction target would increase Greece's obligation to reduce non-ETS emissions. The proposed expansion of the ETS to cover emissions from marine shipping would have notable impacts on Greece, as shipping is a major sector of the economy and a considerable source of emissions.

Greece's climate policy is centred on transitioning to net zero emissions by 2050 while ensuring energy security, improving economic competitiveness and protecting vulnerable consumers. The NECP is the main document defining the mitigation measures to achieve the 2030 targets and put Greece on a path to a net zero energy system. The NECP measures with the largest emissions reduction potential relate mainly to increasing the deployment of renewable energy and improving energy efficiency.

The NECP and other planning documents give natural gas a major role as a transitional fuel to reduce emissions, not just from lignite-fired generation but also through an

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expansion of the gas network to reduce oil demand from building heating and industry. As a result of the sharp and sustained increase in gas prices and the desire to reduce reliance on Russian energy, the government is revaluating the role of natural gas in the energy system and has taken steps to diversify gas supply and reduce gas demand by accelerating the deployment of renewables and energy efficiency measures. The government has taken steps to reduce the time needed for licensing renewable projects and increase the capacity that will be offered through renewable energy auctions. However, significant investments to expand the natural gas network are still planned, and the government has indicated that it wants Greece to become a regional gas-trading hub.

The government needs to clarify the role of natural gas in the energy system to provide clear signals to investors and ensure that it can meet climate and energy security goals. Some investments to diversify the gas supply away from Russia will likely be needed in the short term. However, the reliance on natural gas as a transition fuel carries risks of stranded assets and continued exposure to volatile gas prices. There should be clear policy support for sustained reductions in natural gas demand. Greece should avoid investments that increase gas demand, such as an expansion of the natural gas network; instead, a focus should be placed on electrification, renewable energy and energy efficiency.

Greece's National Climate Law, adopted in May 2022, strengthened the commitment to achieve climate neutrality by 2050, increased the 2030 total GHG emissions reduction target to 55% and included an 80% reduction target for 2040. It sets crucial legislation regarding decarbonisation in several areas, including a ban on lignite-based electricity generation by the end of 2028 and a ban on the installation of oil-fired heating from 2025. The law requires that from 2030 heating will have to contain at least 30% by volume of renewable liquid fuels. It also requires that five-year carbon budgets for five key sectors of the economy be drawn up by 2024. The sectors obliged to have carbon budgets are not clearly defined. The first budgets are for the period 2026-30.

There is a significant amount of GHG emissions (3.1 Mt CO_2-eq) from oil-based electricity generation on the islands not connected to the main electricity grid. Greece is implementing ambitious projects to connect these islands to the main grid and to install renewable generation and storage capacities to support the phase-out of oil-fired generation on the islands.

Emissions from the transport sector have been slowly rising since 2013, with a temporary drop in 2020 due to the Covid-19 pandemic. Emissions are likely going to rise again as transport demand increases. Greece has launched numerous measures to promote EVs; however, the uptake of EVs and the density of the recharging infrastructure is still low. The obligatory blending rate of bioethanol in gasoline was increased, and an obligation for GHG emissions reduction for fuel suppliers was introduced; however, the old age of Greece's vehicle fleet and the taxation of biofuels at the same rate as fossil fuels hinder further penetration of biofuels. Also, oil products used for domestic marine shipping, ferries, fishing and domestic aviation are exempt from excise duties.

Methane emissions account for only a small share of Greece's energy-related GHG emissions (0.7% in 2020). They come mainly from lignite mining (64%) and are expected to decrease as lignite-fired generation is phased out. However, plans to expand domestic oil and gas production and gas infrastructure could drive higher methane emissions, and the government should consider stricter regulations to limit methane emissions.

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Following the Russian invasion of Ukraine, Greece has taken several steps to reduce reliance on Russian energy imports. Several of these steps will lead to increased emissions in the short term including, the delay of the lignite phase-out to 2028. Other proposed activities, such as increased domestic oil and gas production, create risks of locking in longer term emissions.

In 2021, Greece made major changes to how ETS revenues are allocated, shifting most ETS revenues from the Special Account for Renewable Energy Sources, which supports subsidies for renewable energy projects, to the Energy Transition Fund, which provides direct payments to consumers and companies to reduce the impact of high energy prices. Most ETS revenues are now going to the Energy Transition Fund (74% in 2021 and 75% in 2022). This allocation does not meet the EU requirement that 50% of ETS revenues be spent to modernise the energy system and reduce GHG emissions. Greece has a law requiring 100% of ETS revenues to be spent on domestic climate change and energy projects. However, the allocation of the revenues is decided annually, and no national legislation requires a minimal share to be spent in line with the EU requirements. This is especially a problem due to the rising role of ETS revenues in climate policy financing as a result of high allowances.

Greece is highly exposed to the growing risks of climate change that could threaten its energy system. These include a strong increase in temperature that could drive spikes in electricity demand for cooling while also reducing electricity generation and transmission capacity. A reduction in precipitation is also expected and will reduce the availability of hydro generation and thermal generation (less cooling capacity). In addition, the increased risk of wildfires could cause LULUCF to shift from an emission sink to an emission source.

Greece's National Adaptation Strategy (adopted in 2016) defines the goals, principles and priorities for climate adaptation and lists possible adaptation measures for all environmental and socio-economic sectors that are likely to be significantly affected by climate change. The strategy includes the energy sector as one of 15 priority areas and proposes actions to enhance its climate resilience. The National Adaptation Strategy will be implemented through 13 regional adaptation action plans. The NECP refers to measures included in the National Adaptation Strategy, but the effects of climate change and the possible synergies between adaptation and mitigation actions are not well explored.

Given the notable risks posed by climate change, Greece should take strong steps to enhance the climate resilience of the energy sector. The update of the NECP should include well-defined adaptation measures that clearly support the national and regional adaptation strategies so that there is coherence on climate adaptation between key policy documents. The electricity TSO voluntarily conducted an assessment of climate impacts on electricity demand, supply and infrastructure. The government should consider requiring the transmission and distribution system operators to include a climate risk and vulnerability assessment in their development plans to identify a portfolio of effective adaptation options and better anticipate likely climate impacts on their assets.

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Recommendations

The government of Greece should:

- Adjust the measures in the update of the National Energy and Climate Plan so they align with the National Climate Law and increase EU climate ambitions.
- Reassess the need for investments in fossil fuel infrastructure, taking into account the risk of stranded assets and the need to direct limited capital to investments supporting the energy transition.
- Ensure that at least 50% of revenues from auctioning emissions allowances support the energy transition.
- Clearly define the sectors that will have a carbon budget from 2026 onwards to ensure that all major emissions sources are covered.

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3. Energy efficiency

Key data

(2021)

TFC: 637 PJ (oil 52%, natural gas 9.7%, electricity 28%, bioenergy and waste 7.1%, solar 2.0%, coal 1.2%, heat 0.2%), -20% from 2011 to 2021

TFC by sector: buildings 39%, transport 36%, industry 25%

TFC per capita: 60 GJ/capita in 2021 (IEA average in 2020: 113 GJ/capita), -17% since 2011

TFC per GDP: 3.2 MJ/USD in 2020 (IEA average in 2020: 2.6 MJ/USD), -14% since 2011

Overview

Energy efficiency is the "first fuel of choice" for energy security enhancement and climate change mitigation. Energy efficiency offers cost-effective options for sustained savings in energy demand that, with proper policy support, can be implemented quickly. Given the current energy crisis, Greece has the opportunity to place a strong focus on strengthening energy efficiency measures to reduce fossil fuel demand. This will provide immediate benefits for energy security and contribute to the long-term goal of carbon neutrality.

In response to the 2022 global energy crisis caused by Russia's invasion of Ukraine, the Greek government announced in September 2022 exceptional measures to reduce energy consumption by 10% in the short term and by 30% until 2030. This will be achieved by introducing new measures in the public sector and through existing programmes.

For the medium term up to 2030, the NECP defines energy efficiency targets and a wide range of energy efficiency measures to be implemented across all sectors. Under EU regulation, Greece has set targets for annual energy savings for the 2017-2020 and 2021-2030 periods; the main measure to achieve these targets is a system of energy-saving certificates.

In the building sector, the government is strengthening building codes and has launched a number of investment schemes. These programmes aim to improve the energy performance of public and private buildings, increase the number of net zero energy buildings, and expand the use of renewable water heating. In the transport sector, the country is supporting the uptake of EVs and is investing in improving charging infrastructure. Measures for industry energy efficiency include energy audits and support for efficient equipment, mainly for heating. The Greek recovery and resilience plan also includes a number of investments in energy efficiency.

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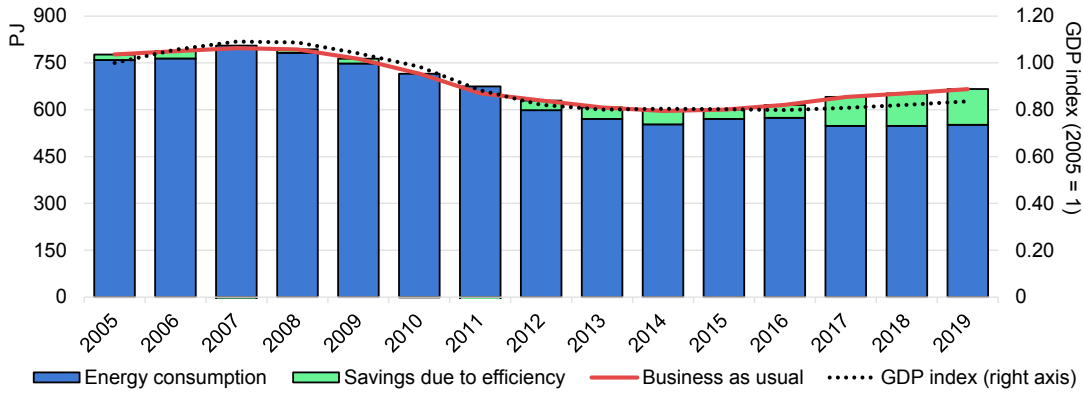
Energy demand and efficiency improvements

Energy demand in Greece significantly dropped between 2007 and 2014, but most of this decrease was due to the effects of the economic crisis. More recently, Greece has achieved some energy savings, especially since 2017, as thanks to energy efficiency improvements, energy consumption did not follow the partial economic recovery (Figure 3.1). These energy savings were achieved mainly in the residential sector, thanks to the shift from oil-fired to more efficient heating systems, and in passenger transport.

Figure 3.1 Estimated energy savings from efficiency in Greece, 2000-2019



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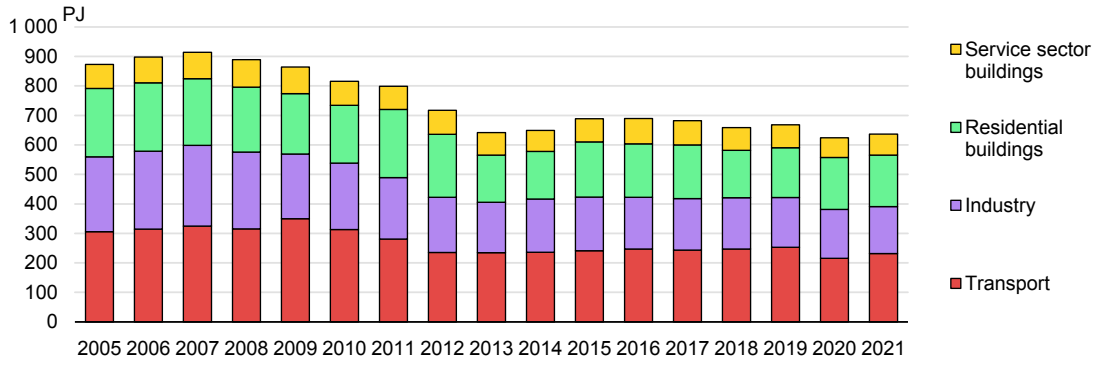
Source: IEA (2022a).

From 2005 to 2021, Greece's TFC decreased by 27%, from 873 PJ to 636 PJ, due mainly to reduced energy use in industry (253 PJ to 159 PJ) and transport (306 PJ to 231 PJ), caused by economic impacts and some efficiency improvements, especially since 2017 (Figure 3.2). The 7% drop in energy demand between 2019 and 2020 is driven by the 15% decrease in energy demand in transport caused by the pandemic. Between 2005 and 2021, energy demand in buildings fluctuated between 233 PJ and 319 PJ, driven mainly by changes in annual heating demand and some improvements in space heating efficiency linked to a transition away from oil-fired heating. In 2021, buildings accounted for 39% of TFC (residential 28% and service sector 11%), followed by transport (36%) and industry (24%).

Figure 3.2 Total final consumption by sector in Greece, 2005-2021



IEA.CC BY 4.0.

Source: IEA (2022b)

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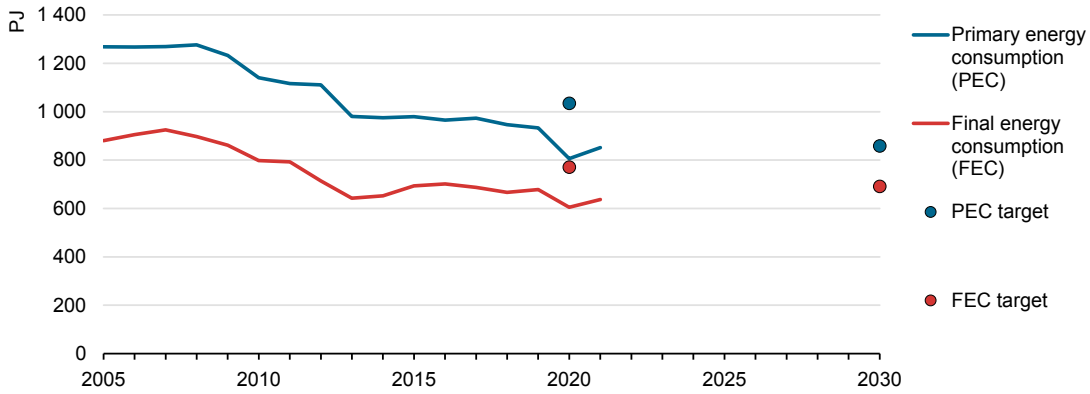
Energy efficiency targets

Under the EU Energy Efficiency Directive (EED), each EU member state has national energy efficiency targets for 2020 and 2030 that contribute to achieving EU-wide targets to reduce energy demand by 20% by 2020 and by 32.5% by 2030 (compared to a business-as-usual projection). The national targets are defined as reductions in primary energy consumption (PEC) and final energy consumption (FEC). Greece's 2020 targets are set in its National Energy Efficiency Action Plan. Greece's 2030 targets are set in its NECP (Figure 3.3). Looking ahead to 2050, Greece's Long-term Strategy sets a road map to renovate almost the entire building stock by 2050, along with intermediate targets of reducing oil use by 90% by 2030 while increasing the use of electricity by 20% by 2030.

Figure 3.3 Greece's 2020 and 2030 energy efficiency targets and status, 2005-2021



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	2020 status	2021 status	2020 targets	2030 targets
Primary energy consumption	806 PJ	851 PJ	1 034 PJ	858 PJ
Final energy consumption	605 PJ	637 PJ	770 PJ	690 PJ

Source: IEA based on data from Eurostat (2022).

Greece achieved its 2021 energy efficiency targets. However, the 2020 targets were adopted in June 2008, just before the start of the global financial crisis, and reflected a positive perspective of the growth of the Greek economy. While Greece successfully implemented some energy efficiency policies in the period leading up to 2020, most of the reduction in energy demand over this period resulted from the negative impacts of Greece's prolonged economic contraction and the Covid-19 pandemic.

In 2021, Greece's PEC and FEC were below the levels set for the 2020 targets, reflecting the government's goal of achieving strong economic growth and improving energy efficiency and keeping energy consumption flat.

In 2021, the 2030 EU-wide GHG emissions reduction target was increased from 40% to 55%. The European Union is making a wide range of policy updates to support the increased target through the Fit-for-55 package. This includes a significant update to the EED, with a proposal to increase the 2030 target for reducing EU-wide energy demand from 32.5% to 36% for FEC and from 32.5% to 39% for PEC, or 9% lower than the 2020 reference scenario projections. Given the increased EU ambitions for energy savings and the European Commission's indication that Greece's existing 2030 targets are of low to moderate ambition, it is likely that Greece will need to increase its 2030 energy efficiency targets and enhance supporting measures. In addition, in May 2022, the European

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Commission issued a new communication (REPowerEU) that proposes further tightening the 2030 energy efficiency target for member states, with a reduction of 13% from the 2020 reference scenario projections (EC, 2022).

Efficiency policy and measures

The NECP is the main document defining Greece's energy efficiency policy until 2030. The Long-term Strategy defines energy efficiency policies to support the achievement of carbon neutrality by 2050. Most of these measures focus on specific sectors. Building sector measures provide a variety of incentives for thermal renovations and upgrading heating and cooling systems. Transport sector measures focus on increasing the adoption of EVs, improving the efficiency of gasoline and diesel vehicles, and on a modal shift away from private vehicles. Industry sector measures consist mainly of energy demand audits.

Energy savings requirements under Article 7 of the Energy Efficiency Directive

Under Article 7 of the EED, Greece had a target of achieving cumulated energy savings for 3 333 thousand tonnes of oil equivalent (ktoe) (140 PJ) between 2017 and 2020. In its National Energy Efficiency Action Plan of 2017, the government indicated a number of measures in different sectors to achieve this target. The measures expected to deliver the highest amount of savings were "energy managers and action plans for public buildings" (18 PJ) and "obligation schemes" (14 PJ). Data on achieved energy savings show that the energy managers delivered much fewer savings than expected (0.2 PJ), while the Energy Efficiency Obligation schemes overachieved their target, reaching 61.4 PJ of cumulated energy savings. However, total cumulated energy savings from 2017 to 2020 were 101 PJ, falling short of achieving the target of 140 PJ.

Greece's Energy Efficiency Obligation Scheme (EEO) started in 2017 and is managed by the Centre for Renewable Energy Sources and Saving. Obligated parties are electricity, gas, oil products suppliers or retailers whose market share is higher than 1%. The number of obligated parties was 35 in 2022. Obligated parties are awarded certificates (white certificates) for verified energy savings and must achieve certified energy savings according to annual targets through their own efforts or by purchasing certificates from other obligated parties. There is no market platform for certificate trading, and the EEO excludes third parties from receiving and trading certificates. Penalties are foreseen if obligated parties do not fulfil their annual target. Actions tackling fuel poverty are eligible for a bonus factor of 40%. From 2017 to 2020, the EEO exceeded its target demand reduction by 80%, with annual savings growing from 7.3 PJ to 36 PJ.

A new cycle of energy savings is expected under the EED for EU countries from 2021 to 2030. Greece is expected to achieve cumulative energy savings of 7 229 ktoe (305 PJ) by the end of this period. In the government's plan, energy efficiency obligation schemes will account for 20% (61 PJ) of the total cumulative objective, whereas a total of 9 alternative policy measures are to be implemented to cover the remaining part of the objective. These include energy upgrading of public and private buildings; improving energy efficiency through energy service companies; energy managers in public buildings; upgrading pumping, lighting and transport infrastructures; and promoting alternative fuels in road transport.

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Examples from other countries, such as France and Italy, show how an energy certificate scheme can drive very high energy savings if well implemented and regularly revised (Box 4.1). In both countries, certificates can be traded on a dedicated platform, accessible to third parties, creating a market of energy-saving certificates and increasing their demand, with the effect of increasing incentives to achieve energy savings.

Box 3.1 The Italian and French energy-saving certificate systems

Italy's White Certificates or Energy Efficiency Titles (EETs) scheme started in 2005 and is widely regarded as the most cost-efficient Italian energy efficiency policy. In 2016-2020, the EET mechanism contributed to achieving 6.7 million tonnes of oil equivalent (Mtoe) (280 petajoules [PJ]) cumulative energy savings, of which 53% were achieved in the industrial sector. The EETs also have a major role in Italy's energy efficiency strategy to 2030. They are expected to contribute to 0.223 Mtoe (9.3 PJ) of energy savings per year between 2021 and 2030, equivalent to 12.3 Mtoe (515 PJ) of cumulative savings to 2030, or about 21% of the overall target under Article 7 of the Energy Efficiency Directive.

The scheme promotes energy efficiency across end-use sectors (industry, residential buildings, public lighting and transport). It does so by assigning annual mandatory savings quotas to electricity and natural gas distributors with more than 50 000 end customers. It is possible to fulfil the mandatory savings quota by either directly implementing energy efficiency projects or purchasing the EETs on the market.

Each certificate is awarded for one tonne of oil equivalent (toe) of certified energy savings achieved through energy efficiency measures and projects. EETs are securities that can be traded on a dedicated market platform managed by the public company "Gestore dei Mercati Energetici" (GME) or through bilateral negotiations.

To ensure the scheme can deliver the expected savings for 2030, the government introduced several changes in 2021 aimed at strengthening the EET system, including setting 2021-2024 obligation quotas, extending the types of eligible energy efficiency projects and introducing auctioning.

France's energy-saving certificates system (white certificates) started in 2006 and is one of the country's key policies to achieve energy savings in the residential, tertiary, industry, transport and agriculture sectors, including installations subject to the European Union's Emissions Trading System. These certificates, so-called "*certificat d'économies d'énergie*" (CEE), are issued by the Ministry of Ecological Transition to eligible stakeholders that have undertaken energy-saving operations and can be traded with a unit expressed in "MWh cumac", corresponding to the cumulative discounted saving of 1 MWh (3.6 GJ, 0.09 toe), over the lifetime of a product or investment. The CEE started in 2006, and its fourth application period ended on 31 December 2021. For the fourth period from 2018 to 2021, the target was 2 133 terawatt hours (TWh) (12 Mtoe or 502 PJ equivalent of energy saving per year). The government aims to further improve the performance and efficiency of the CEE during the fifth period, which began on 1 January 2022. The French Court of Auditors, the Ministry of Ecological Transition and the General Inspectorate of Finance review the CEE alongside the French energy agency ADEME with a full evaluation every three to four years.

Sources: IEA (2021; 2023).

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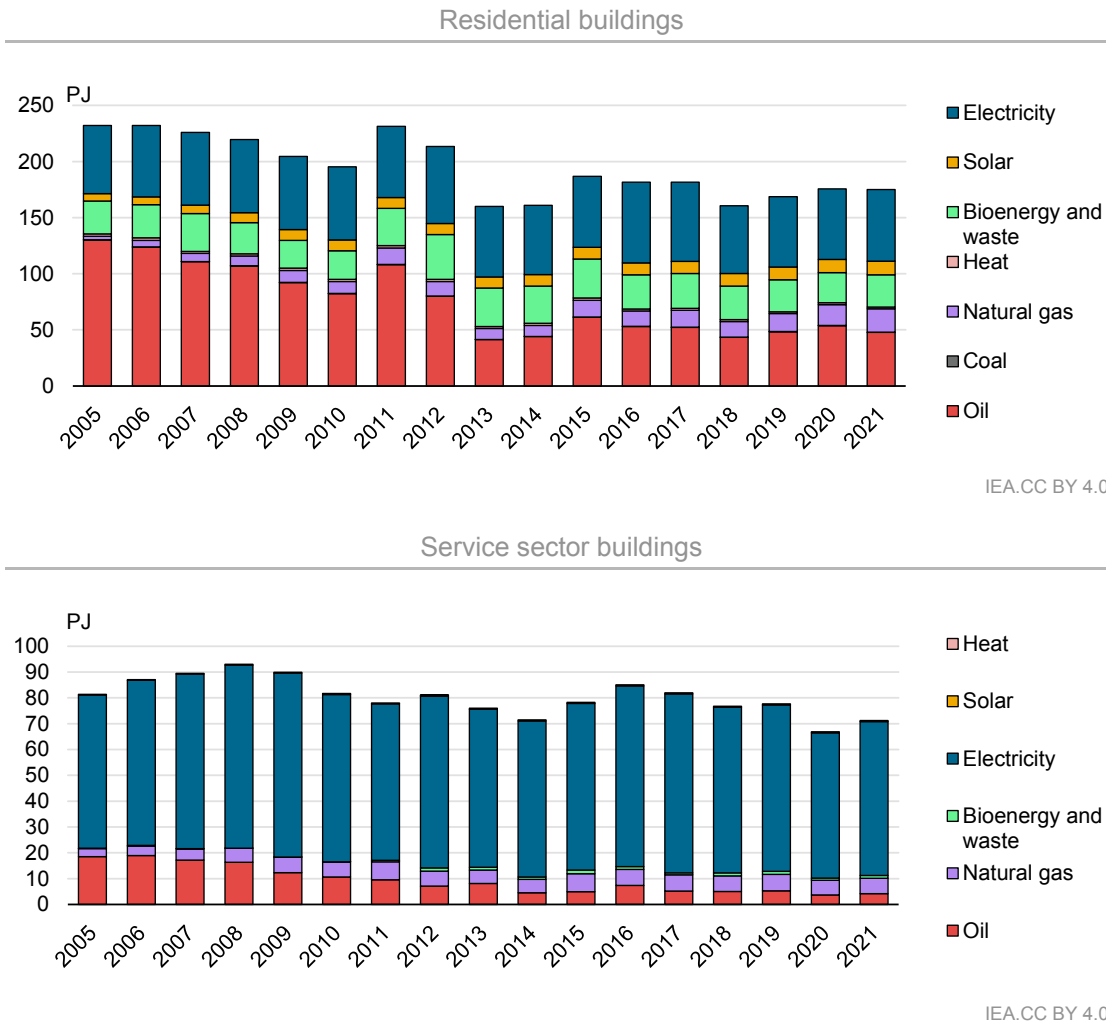
Building energy demand and efficiency

Total final consumption of buildings dropped in line with the reduction in economic activity from 2010 to 2014, has fluctuated since, and was 246 PJ in 2021, or 39% of TFC. Residential buildings energy demand is more than twice that of service sector buildings, and accounts for 71% of buildings' TFC in 2021 (Figure 3.4).

According to the most recent data available from the EU Building Stock Observatory, in 2015, there were 4.8 million buildings in Greece, of which 95% were residential. Among residential buildings, 2.1 million were single-family houses and 2.5 million were multi-dwelling buildings. More than half (55%) of residential buildings and 39% of service sector buildings were built before 1980, when regulations on thermal insulation entered into force. In the period 2011-2018, more than 1.5 million energy performance certificates were issued. According to these, two-thirds of residential buildings have an energy class between E and H (lowest class).

Figure 3.4 Total final consumption in the building sector by source in Greece, 2005-2021



Source: IEA (2022b).

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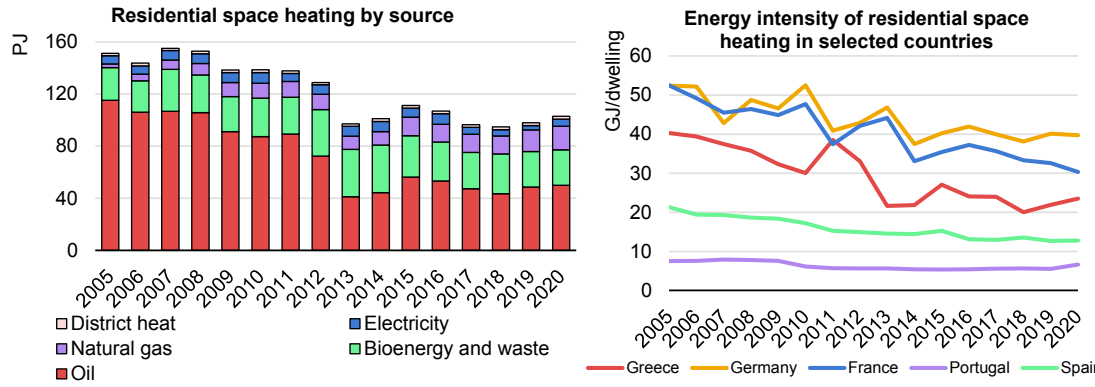
From 2007 to 2021, electricity was the main source of energy in buildings (50% in 2021), playing an important role in residential buildings (36%) and almost monopolising energy demand in service sector buildings (83%). The second-largest source of energy for buildings is oil (21% in 2021), accounting for a large share, especially in residential buildings (27%). Bioenergy and waste supplied 12% of energy to buildings in 2021. Natural gas use has been generally low compared to other IEA countries, covering 11% of building TFC in 2021. Solar thermal covers 5.1% of energy demand in buildings, the highest share among IEA member countries, thanks to continued policy support for this technology (see the section on building energy efficiency policy). District heat covers only 0.6% of building TFC and coal 0.1%.

Most of the energy (56.2%) in the residential sector is used for space heating, which is largely provided by diesel- and biomass-fired boilers. Appliances accounted for 17% of residential energy consumption, water heating for 14%, cooking for 8.2% and cooling for 4.3%. The energy mix of residential space heating has seen a decreasing use of oil, especially between 2010 and 2013, and this corresponded to a decreased energy intensity of space heating per dwelling (Figure 3.5). However, Greece's energy intensity of space heating is still higher than Spain's and Portugal's.

Figure 3.5 Energy consumption by source and energy intensity of residential space heating, 2005-2020



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Source: IEA (2022a).

Building energy efficiency policy

The Greek government aims to improve the energy efficiency of buildings by strengthening minimum requirements and investment programmes, also in the context of the post-pandemic economic recovery and with special measures to save energy following Russia's invasion of Ukraine. The government is setting minimum requirements for buildings and promoting incentive programmes, with the target of renovating 60 000 dwellings per year, corresponding to cumulative energy savings of 306 PJ from 2021 to 2030.

Minimum requirements for buildings

In the new Climate Law of 2022, the government has set regulations to limit the installation and use of heating oil boilers. The installation of oil boilers will no longer be allowed from 2025, and from 2030, oil for heating will have to contain at least 30% by volume of renewable liquid fuels.

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An Energy Performance Certificate (EPC) must be issued when a building is built, purchased, rented or after a major renovation. An EPC must also be issued before and after the completion of renovations funded by government subsidies to confirm that the required level of improvement has been achieved. EPCs are issued by entities accredited by the Ministry of Environment and Energy. An EPC can provide a basis for consumers to understand their building's energy efficiency performance with the classification from A+ to H. However, in 2021, only 38% of residential buildings had an EPC, greatly limiting information for consumers.

Greece is implementing the European Union's Energy Performance of Buildings Directive. Every building in the public sector built since 2019, and all buildings (public and private) built since 2021, have to be a nearly zero-energy buildings. Since 2021, advertisements for buildings for sale or rent must include the energy efficiency index shown in the EPC. From 2024, all public buildings must have an energy performance certificate of class B or higher. When buildings are built, constructors need to provide technical, environmental and economic feasibility studies for the installation of at least one of the following systems: renewable energy sources, combined heat and power, district heating and/or cooling, or heat pumps meeting the minimum EU requirements.

Since 2011, new buildings are obliged to cover at least 60% of the energy needs for water heating with solar thermal or any other renewable energy source. Buildings not complying with this standard need to provide technical documentation proving that it is not technically feasible. This policy drove up the share of solar thermal in buildings. In 2021, Greece was the IEA member country with the highest share (5%) of solar thermal in this sector.

Investments programmes

The Electra programme, launched in 2020, aims to improve the energy efficiency of public buildings (Greece, Ministry of Environment and Energy, 2020). The programme is funded from 2022 to 2026 with EUR 500 million by the Deposit and Load Fund of the European Investment Bank, EUR 170 million from the EU Recovery and Resilience Facility, and EUR 250 million in private investments. The programme includes public buildings with an energy class between C and H that have not yet undergone radical renovation. The programme finances the renovation of the whole building, aimed to improve energy efficiency and reach class B and reduce energy demand by 30%, with the mandatory appointment of an energy manager. Financed interventions include replacing windows, modernising heating and cooling systems, and installing renewables and electricity storage. The programme encourages the participation of energy service companies to perform the renovation works.

The Savings at Home programme aims to improve the energy efficiency of residential buildings and is funded by EU programmes, including the Recovery and Resilience Facility. The programme provides interest-free loans and grants for the installation of renewables and energy efficiency measures. The yearly rounds from 2018 to 2020 received a total of 94 094 applications and provided grants for EUR 1.3 billion and loans for EUR 113 million. The 2021 round of the programme had a budget of EUR 1.14 million, a maximum eligible intervention of EUR 28 000 and targeted support for vulnerable households. The programme ran until the end of the first half of 2022, with a record high number of applications (87 578).

The contributions for energy efficiency improvements of the Electra and Savings at Home programmes are included in the "Renovate" component of Greece's recovery and

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resilience plan (Greece, 2022). With a total budget of EUR 2.7 billion, this component is the second-largest of the plan and is centred on renovation and energy upgrading of buildings, including residential, business (secondary and tertiary sector) and public buildings and public lighting points. The recovery and resilience plan also supports the publication of Greece's Action Plan to Combat Energy Poverty, which provides a framework for energy upgrades of residential buildings of energy-vulnerable households (see Chapter 1).

A programme called "Recycle-Change Device" started in June 2022. Through this programme, Greek households can receive a subsidy to replace up to three old electric appliances with new ones, including air conditioners, refrigerators or freezers. Households can apply to the programme through a digital platform and need to return the old appliances to receive the subsidy. The subsidy rate ranges from 30% to 50% of the cost of the appliance. It is estimated that this programme will reduce electricity demand by 209 GWh (0.7 PJ) per year and support annual savings of EUR 40 million.

Additional energy savings to tackle the 2022 energy crisis

In September 2022, the government presented an exceptional plan to save energy in response to the global energy crisis following Russia's invasion of Ukraine. The plan includes measures to save 10% of energy in the short term and 30% by 2030, with savings achieved mainly in the public sector. Among the main measures are:

- Public bodies owning buildings must appoint an energy manager whose task is to optimise the use of energy in public buildings.
- Updated regulation for the maintenance and operating temperatures of heating and cooling systems. These include a minimum temperature in the summer of 27°C and a maximum temperature in winter of 19°C, and switching off heating and cooling in areas without workers.
- Mandatory installation of shading systems to limit heating from solar radiation in the summer and encouraging the use of natural ventilation, especially at night.
- Optimisation of street and decorative lighting, with a target of reducing energy consumption by 35-50%. The central government has set a target for local governments to achieve 10% of energy savings from street lighting with respect to the previous year as a condition for receiving certain aids for energy costs. An additional 5% of public aid will be provided the next year for those services that achieve a savings of 15%.
- Improve the energy efficiency of pumping stations of water and sewage facilities, for example with the installation of inverters.

A public electronic platform will monitor the implementation of these and the achievement of the targets.

National Long-Term Renovation Strategy for 2050 with intermediate targets in 2030

The Long-Term Renovation Strategy establishes a road map to achieve the renovation of almost the entire building stock by 2050. In the residential sector, the focus is placed on a transition of the energy mix by reducing the use of oil by 90% by 2030, replacing it with natural gas, renewables and electricity, combined with energy savings. The strategy also highlights the need to reduce the use of conventional biomass, with the aim of reducing local air pollution. By 2050, oil-fired heating will be totally eliminated in the residential

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sector, with radical independence of the sector from fossil fuels, which will be replaced by zero-emission gas such as biomethane and hydrogen, and the use of renewable electricity with heat pumps.

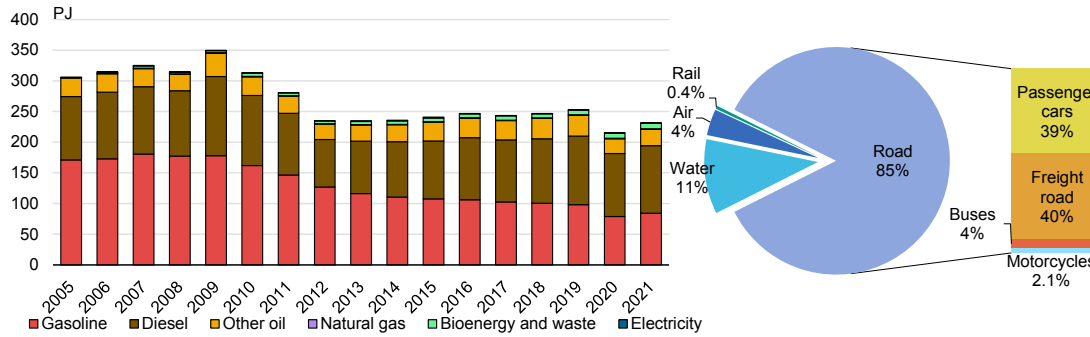
Electrification is a key pillar of the Long-Term Renovation Strategy, with a target of increasing the use of electricity by 20% in 2030 (compared to 2015). Electricity is expected to cover 47% of energy demand in the residential sector in 2030 and reach 81% in 2050, as the use of heat pumps is expected to increase significantly, combined with the renovation of buildings. The share of electricity in residential buildings was 36% in 2020. In the service sector, electricity is expected to cover 87% of demand in 2030 and almost 100% in 2050. The share of electricity in service sector buildings was 84% in 2020. The strategy also relies significantly on a higher rate of major renovations of the buildings envelope, with a goal of achieving annual energy savings of 1.6% per year through 2050, resulting in a cumulative drop of 46% in energy demand.

Transport energy demand and efficiency

Transport sector TFC decreased from 306 PJ in 2005 to 232 PJ in 2021, when it accounted for 36% of TFC (Figure 3.6). In 2021, the Covid-19 pandemic and the related restrictions caused a 65% drop in energy demand in transport compared to 2019. Diesel is the main fuel used in the transport sector, covering 48% of transport energy demand in 2021, followed by gasoline (36%). Other oil products (LPG, kerosene and fuel oil) accounted for 12% and biofuels for 3.9%. Natural gas accounted for 0.4% of transport sector energy demand in 2021. The share of cars fuelled with LPG (6.5% in 2020) is double the EU average (3%).

Most energy demand in the transport sector comes from road transport, accounting for 85% of transport energy use in 2019. Domestic navigation accounts for 11%, while the IEA average is 4%. Domestic aviation counts for 4% and rail for 0.4% (the IEA average is 4%). While road transportation relies mostly on oil products, electricity is used mainly in rail and accounted for around 0.2% of total transport demand. Almost two-thirds of energy consumption of rail is provided by electricity; the rest is covered by diesel.

Figure 3.6 Total final consumption in transport by fuel, 2005-2021, and by mode in 2019



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Source: IEA (2022b).

Energy consumption of passenger cars per passenger-kilometre (pkm) has almost halved, from 1.7 MJ/pkm in 2005 to 0.96 MJ/pkm in 2019, reaching lower levels than Spain,

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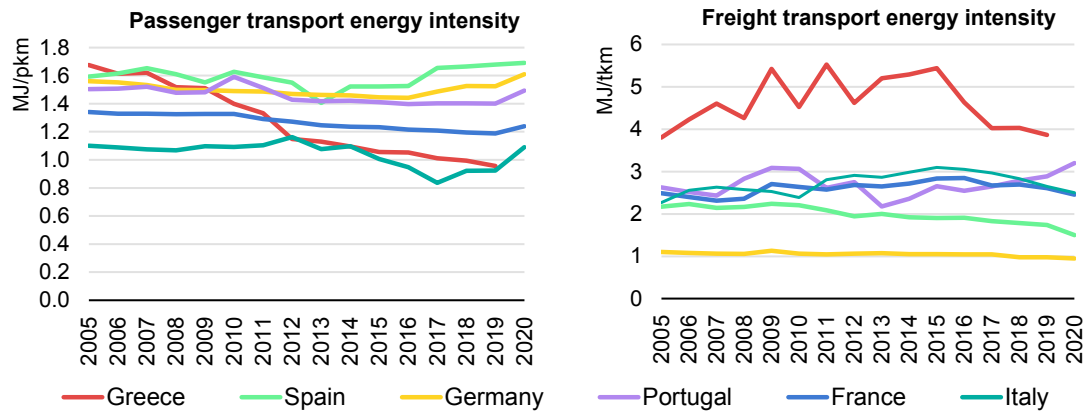
Germany, France and Portugal (Figure 3.7). This is mostly because of the high average of passenger occupancy, the second-highest among IEA member countries (1.82 versus the IEA average of 1.48). The economic crisis following 2008 had a significant impact on the increase of pkm of cars, driving down the indicator, as the purchasing power of the population experienced an exceptional decrease and car sharing became one cost-saving measure for families. The average age of Greek passenger vehicles is 16.6 years, while the EU average is 10.7 years.

The energy efficiency of freight transport is very low, with a high and not significantly improving energy consumption per tonne-kilometre (tkm). The poor energy efficiency of freight transport is particularly critical in Greece, as the share of road freight in transport energy consumption (40%) is among the highest of IEA member countries. The average age of Greek freight trucks is 21.4 years, the oldest in the European Union, where the average is 13.9 years.

Figure 3.7 Transport energy intensity in selected IEA countries, 2005-2020



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Note: Data for Greece are only available until 2019.
Source: IEA (2022b).

Deployment of EVs, including battery electric vehicles and plug-in hybrid electric vehicles, has been rising rapidly in Greece over the last two years (Figure 3.8). From 2014 to 2022, the number of EVs increased from just 62 to 18 575. Growth has dramatically steepened since 2020, increasing almost sixfold by 2022. While Greece's EV market is expanding, it is still lagging behind other EU countries. In 2022, the share of EVs in the total car fleet was just 0.3%, compared to 2.3% in Europe; the share of EVs in new registrations was 7.9%, compared to the European average of 21.6%. Publicly available charging points have also ramped up since 2018, from 50 to 1 020 in 2022.

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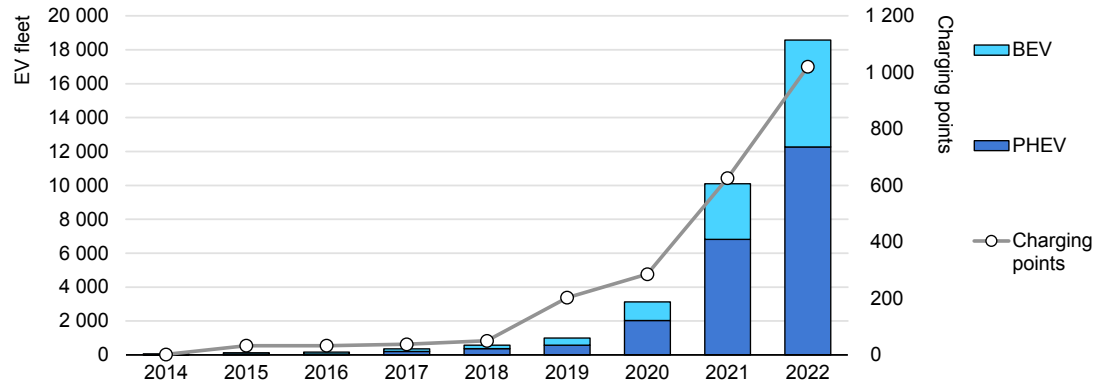
Figure 3.8 Registered electric vehicles and public charging points in Greece, 2012-2022



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Source: EAFO (2023).

Transport energy efficiency policy

The Greek government aims to improve the efficiency of the transport sector and reduce its impact on climate by increasing electrification and the use of alternative fuels and promoting a modal shift to public transport. A sound energy policy in the transport sector involves a comprehensive approach following the "avoid, shift, improve and finance" model. In this approach, measures are adopted to avoid the need for transport, shift to more efficient transport modes such as public transport, improve the efficiency of transport devices and infrastructure, and finance the overall reform in a just way.

Greece aims to significantly increase the electrification of its transport sector in the coming years as a key tool to achieve its climate goals. The NECP sets clear yearly targets for the adoption of passenger EVs in the country's vehicle fleet until 2030, with milestones of 10.1% EVs in new passenger car registrations by 2024 and 30% by 2030. The government is preparing a national e-mobility strategy.

In July 2020, the Greek government passed a law for promoting electromobility in Greece. The law introduces grants for the purchase of electric cars, motorcycles, bicycles and scooters; allocates free-of-charge parking spaces to EVs (with emissions lower than 50 g CO_2/km); lowers taxes for EV-related industry; and promotes spatial and urban planning favourable to EVs, such as the installation of public charging stations. The law also increases taxes for imported old vehicles with high emissions.

The Climate Law 2022 requires that as of 2024, at least a quarter of new company cars must be EVs (battery only or plug-in hybrid), emitting less than 50 g CO_2/km. Moreover, from 1 January 2026, all new taxis circulating in the prefecture of Athens and Thessaloniki, as well as one-third of new cars registered for rental purposes, must be battery electric. In addition, the law introduces the obligation to sell only zero-emission vehicles starting in 2030.

The programme "I Move Electric" supports the purchase of EVs in Greece. In its first wave, it offered subsidies of up to EUR 6 000 for the purchase of electric cars and motorcycles. The first cycle of the programme was largely successful. It significantly contributed to increasing the number of EVs, overshooting the initial target. Since July 2022, a second version of the programme has been in place (I Move Electric II), with a budget of

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EUR 50 million for 2022-2023. It includes an increase in the subsidy for individuals and companies for the acquisition of electric cars and motorcycles. These subsidies cover up to 30% of the price, up to a maximum of EUR 8 000. The purchase of a smart home charger can be subsidised up to EUR 500. An extra bonus of EUR 1 000 is given for scrapping an old car. Moreover, an extra bonus of EUR 1 000 is given to individuals under 29 when buying an electric car and EUR 500 when buying an electric two- or three-wheeler.

Subsidies are also provided for business cars and taxis. Taxis can receive up to EUR 17 500 plus another EUR 5 000 for scrapping an old taxi and replacing it with a battery electric one, financed by a dedicated budget of EUR 40 million from the recovery and resilience plan. The target is to replace 2 000 taxis. This programme also includes tax benefits for private individuals and businesses owning EVs, such as an exemption from the registration tax, ownership tax, luxury commodity tax and a reduced VAT rate for EV purchases (13% instead of 24%). In addition, the e-mobility law bans or places high fees on the import of older passenger vehicles.

Greece's recovery and resilience plan also includes EUR 80 million to support the installation of about 8 000 publicly accessible EV charging points. Greece has targets to have 12 000 charging points in 2025 and 25 000 in 2030. The government is working on an online platform that will show all publicly accessible charging points (Greece, Ministry of Infrastructure and Transport, 2022).

The Greek government is expanding the electrification of the rail network along multiple lines. The ministry has signed a public service obligation contract with the national rail company, which is expected to invest in the acquisition of electric and hydrogen-fuelled trains. While in the short term hydrogen trains are aimed to cover non-electrified portions of the rail network, in the long term they will be the first choice for any type of line, provided that hydrogen is generated using renewable energy sources. The government is also planning to extend the railway network and increase rail connections with Greece's main ports.

Since 2021, all regional authorities and certain municipalities have been obliged to prepare sustainable urban mobility plans. These plans include guidance for implementing policies that promote the use of public transport, walking and cycling, and mobility management. The government can financially support the measures proposed in the sustainable urban mobility plans as part of the Public Investment Program or other financial instruments.

Six Greek cities, including Athens, have joined the European Union's initiative to achieve carbon neutrality by 2030. Under this initiative, Athens has implemented entry restrictions on trucks into the city centre and required trucks to meet Euro 5 emission standards to enter other areas of the city. The other Greek cities participating in the programme are considering bans on old and polluting passenger vehicles and trucks.

Industry energy demand and efficiency

The industry sector's TFC was 159 PJ in 2021 and accounted for 25% of TFC. The industry sector (including non-energy use)[1] has been the sector with the lowest share of TFC

[1] Non-energy use refers to fuels used as raw materials and not used as fuel or transformed into another fuel. This comprises typically raw materials used in the chemical and petrochemical sector.

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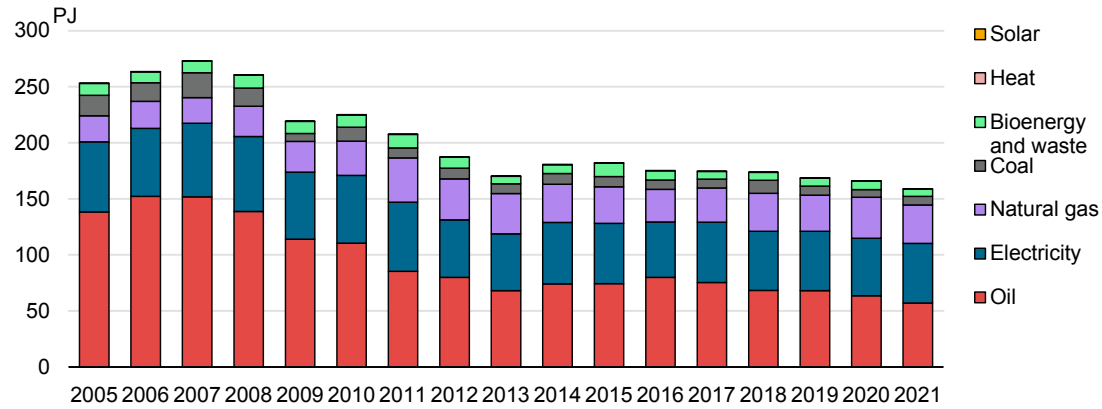
since 2007. Industrial energy consumption declined markedly (by 38%) between 2007 and 2013, partly because of the global financial crisis. Since then, energy use by industry has stabilised around an average of 172 PJ (Figure 3.9). In 2021, the main energy source in the industry sector was oil (36%), followed by electricity (31%), natural gas (22%), coal (5%), and bioenergy and waste (4%).

The largest energy-consuming industrial sectors in 2021 were non-metallic minerals, chemical and petrochemical, and non-ferrous metals, each accounting for 19% of industrial consumption. The other main sectors in terms of energy demand were food and tobacco (14%), agriculture/forestry (9%), construction (7%), iron and steel (4%), mining and quarrying (3%), machinery (3%), and paper (2%). Energy efficiency in the manufacturing sector has improved somewhat, as its energy intensity per value added decreased from 6.0 MJ/USD in 2016 to 4.4 MJ/USD in 2019, which is lower than the IEA average of 5.3 MJ/USD in the same year.

Figure 3.9 Total final consumption in industry by source in Greece, 2005-2021



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Source: IEA (2022a).

Industry energy efficiency policy

As mandated under Article 8 of the EED, Greece requires large industries to either conduct an energy audit every four years or implement an energy or environmental management system such as ISO 50001. The integrated management system in Greece was expanded in 2016 according to the ISO 50001 standard. Companies are not obliged to implement the measures identified in the audit, and the government does not provide support for conducting the audits or implementing the identified measures.

The “Green Businesses” programme encourages the deployment and marketing of environmentally friendly products, while the “Support to Improve Energy Efficiency in Industrial Processes” specifically targets the reduction of energy demand and the cost and climate impact of industrial processes.

The government has introduced in 2023 the “Energy Efficiency Improvement in SMEs” programme. The programme is co-financed by the European Regional Development Fund and the Operational Programme Competitiveness, Entrepreneurship and Innovation 2014-2020. The programme has a budget of EUR 700 million and aims to support energy efficiency improvements in 25 000 companies, of which 3 400 are new companies and

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more than 6 500 have research and innovation action plans. The programme provides a subsidy of 40% for each investment, from a minimum of EUR 30 000 to a maximum of EUR 1 million.

Assessment

Energy efficiency should be the "first fuel of choice" for energy security enhancement and climate change mitigation. Energy efficiency offers cost-effective options for sustained savings in energy demand and can be implemented quickly with proper policy support. Given the current energy crisis, Greece should place a strong focus on strengthening energy efficiency measures to reduce fossil fuel demand. This will provide immediate benefits for energy security and contribute to the long-term goal of carbon neutrality.

In Greece, the buildings sector has the largest share of total final consumption (39% in 2021), followed by transport (36%) and industry (25%). From 2005 to 2021, Greece's TFC dropped by 27%, to 637 PJ. Most of this reduction occurred from 2008 to 2014 and was driven by the economic crisis. From 2014 to 2019, energy demand remained relatively stable even as GDP recovered, thanks to energy efficiency improvements. These energy savings were achieved mainly in the residential sector – thanks to a shift from oil-fired to more efficient heating systems – and in passenger transport.

Greece overachieved its 2020 targets for energy consumption. However, the 2020 targets were adopted just before the global financial crisis in 2008 and reflected a positive perspective on the growth of the Greek economy. In 2020, Greece's primary and final energy consumption was already below the levels set for the 2030 targets.

Under Article 7 of the EU Energy Efficiency Directive, Greece had a target to achieve 140 PJ of energy savings from 2017 to 2020. To support the achievement of this target, Greece developed an Energy Efficiency Obligation scheme. There is no market platform for certificate trading and the EEO excludes third parties from receiving and trading certificates. From 2017 to 2020, the EEO exceeded its target demand reduction by 80%, with annual savings growing from 7.3 PJ to 36 PJ. However, Greece fell short of achieving the overall energy savings target, as the other measures identified to achieve the target were not as successful, and the overall savings (101 PJ) were 28% lower than the target of 140 PJ.

The measure with the largest energy savings achieved through the EEO was consumer awareness campaigns (47% of total EEO savings). Most of the savings were achieved in the transport sector (60%), while industry contributed only 8% to the total savings.

Greece plans to cap the savings that can come from awareness-raising campaigns at 30% and will require that technical measures cover at least 30% of EEO savings required for the obligated parties. Greece also plans to open its EEO to third parties (including energy service companies) and create a market platform for certificate trading to drive the implementation of cost-effective measures. When updating its EEO, Greece should closely examine lessons from other countries. These include careful design, monitoring and updating of the market mechanism for certificate trading and ensuring that saving verification procedures are timely and transparent to allow quick processing and avoid fraud.

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An update of the EED requires Greece to achieve cumulative energy savings of 305 PJ from 2021 to 2030. The government plans for the EEO to cover 20% of the savings required to meet this target. The remaining required savings would be covered by nine alternative policy measures, mostly focused on the building sector.

The NECP includes 12 priority policy areas and 47 measures covering the energy efficiency for buildings, transport, industry and energy supply infrastructure. The NECP does not include a cost-effectiveness assessment in the selection of priority areas for energy efficiency improvements.

Buildings

The Greek government supports energy efficiency in buildings through strengthened minimum requirements for new buildings and investment programmes supporting renovations of existing buildings. The Climate Law includes a ban on the installation of oil boilers from 2025 onwards. As of 2030, oil for heating will have to contain renewable liquid fuels of at least 30% by volume. The government has also published a plan with intermediate milestones to increase the number of nearly zero-energy buildings and renovate almost 100% of the building stock by 2050. Investment programmes support the renovation of buildings, including an investment of over EUR 5 billion from the recovery and resilience plan.

The government has set a target to renovate 60 000 buildings per year until 2030 to achieve cumulative energy savings of 7.3 Mtoe (306 PJ) from 2021 and 2030 and create and maintain over 22 000 new full-time jobs. Incentives for these renovations will be provided through EU funding and leveraging private financing. As Greece has around 4.8 million buildings, reaching 100% net zero buildings by 2050 requires a notably higher renovation rate of around 150 000 buildings per year.

The “Saving at Home” programme (co-financed by the European Union and Greece) offers interest-free loans and subsidies to replace windows and doors and to upgrade thermal insulation and heating systems. This programme should be expanded with additional funding to meet the high consumer demand for renovation projects. In addition, the focus should be on deep renovations that combine improvement in thermal performance with the deployment of heat pumps to allow for proper sizing of the heating and cooling system to deliver the maximum benefits for energy savings and reducing energy bills. Low-income households should be prioritised, with an appropriate level of financial and technical support to ensure that they can take full advantage of the programme.

Energy performance certificates must be issued when a building is built, purchased or rented, and before and after a major renovation. However, in 2021, only 38% of residential buildings had an EPC, greatly limiting information for consumers. More effort is needed to increase the share of buildings with an EPC. The relatively low number of EPCs issued can be attributed to a shortage of assessors, a lack of enforcement mechanisms, and low awareness among owners and builders.

The Electra programme aims to improve the energy efficiency of public buildings and has a budget of EUR 670 million (from the European Union) for 2022 to 2026, topped up with EUR 250 million of private investments. It supports deep renovations of public buildings to reach class B and achieve a 30% reduction in energy demand. The government should

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take steps to accelerate this programme (e.g. by front-loading the funding) so it can deliver savings in the near term as part of the effort to use energy efficiency to limit the impacts of the energy crisis.

Transport

The NECP includes a priority area "replacement of polluting passenger vehicles and freight vehicles". Greece's passenger and freight fleets are significantly older than the EU average.

The government is focusing its transport policies on the electrification of the fleet, with a target of achieving 30% of EVs in new passenger vehicle sales by 2030. A number of programmes provide subsidies for the purchase of EVs and the installation of EV chargers for private citizens, companies and taxis. EVs also benefit from tax exceptions or reductions.

The government also intends to improve urban planning and support the use of active transport modes, such as walking and cycling. In 2021, the government published guidelines for developing and implementing sustainable urban mobility plans. The design and implementation of these plans are not mandatory for local authorities, but the government plans to financially support their implementation.

A comprehensive approach should be taken to design urban transport systems. Following the "avoid, shift, improve and finance" framework, the development of public transport systems should go hand in hand, for example, with parking regulation to avoid passenger vehicle use and the provision of economic incentives to facilitate the replacement of old vehicles with new ones. In this regard, introducing a scrapping programme to replace older vehicles with newer ones will have an immediate impact on reducing the demand for oil products.

Policy needs to be in place to regulate the large freight companies and facilitate the optimisation of their energy consumption. Establishing a reporting system is one way to understand those entities' energy consumption, which can be followed by setting a target for the respective entities to meet. The government of Greece can prepare guidelines on the methods to improve freight transport efficiency, such as inter-company co-ordination on logistics and the use of digital technologies.

Industry

The NECP includes a priority area for the "implementation of energy efficiency and the competitiveness of the industry sector". However, energy efficiency policy in the industry sector is limited and relies mainly on the EU requirement for large industries to either conduct an energy audit every four years or implement an energy or environmental management system such as ISO 50001. Companies are not obliged to implement the measures identified in the audit. The government should consider requiring companies to implement all measures identified in the audit that have a payback period under a certain number of years. This is standard practice in many IEA countries.

An annual award system can be introduced to commend the best-performing companies based on the total audit results. Also, based on the result of the energy audits, a class evaluation system (similar to an EPC) can be introduced. Systems can be established to advertise the ranking of audit results as a means to encourage further efforts.

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A new incentive for the industry sector, similar to the Electra programme for public buildings, is under preparation to facilitate energy efficiency investments. Under this framework, applicants should meet pre-conditions, such as the introduction of an energy manager.

More work is needed to drive energy savings in industry. Greece should publish guidelines on efficient technologies and practices for the energy-intensive industry subsector. This can be done by working together with the respective industry associations to increase their engagement.

Recommendations

The government of Greece should:

- Quickly strengthen energy efficiency and conservation measures to reduce fossil fuel demand in all sectors. This will provide immediate benefits for energy security and contribute to the long-term goal of carbon neutrality.
- Allow third parties to participate in the Energy Efficiency Obligation, introduce a market mechanism for certificate trading and encourage the achievement of permanent savings. This will increase the impact of the Energy Efficiency Obligation and drive cost-effective energy savings across the economy.
- Focus building renovation programmes on deep renovations that combine thermal insulation with heat pumps to deliver maximum benefits for energy savings and reducing energy bills. Priority and adequate resources should be given to vulnerable households.
- Promote the replacement of old vehicles, especially freight trucks, by providing incentives, including a scrapping programme to trade-in older vehicles for more efficient ones.
- Prepare guidelines on efficient technologies and practices for energy-intensive industry subsectors. This can be done through co-operation with industry associations to increase industry awareness and engagement.

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4. Renewable energy

Key data

(2021)

Renewables in total final energy consumption (TFEC): 130.1 PJ/20.4% of TFEC (bioenergy 7.4%, wind 5.3%, solar 4.7%, hydro 3%, geothermal 0.03%)

Renewables in electricity generation (2021): 22.1 TWh or 40.6% of electricity generation (wind 10.5 TWh, hydro 5.9 TWh, solar 5.3 TWh, bioenergy 0.5 TWh)

Overview

From 2011 to 2021, the share of renewable energy in Greece's total final energy consumption (TFEC) increased from 11% to 20%, driven mainly by growing electricity generation from wind and solar PV, steady growth in heating from solar thermal, and a small increase in liquid biofuels in road transport. Over the same period, heating from solid biomass experienced an overall decline (Figure 4.1). In 2021, Greece's share of renewables in TFEC ranked 14th among IEA member countries and close to the IEA average. In the same year, renewables accounted for 22% of Greece's gross final energy consumption, 36% of electricity generation, 36% of heating and cooling demand, and 4.3% of transport (Figure 4.2).[2]

Greece's renewable energy policy aims to accelerate the use of renewable energy, and the government sees renewable energy as essential to achieving 2030 climate targets and long-term goals for net zero emissions. The government aims to boost the use of renewables across the economy, mainly through a strong increase in renewable electricity generation linked to widespread electrification of energy demand, especially for buildings and road transport. There is a focus on deploying solar PV and onshore wind generation, but Greece is also working to deploy its first offshore wind farms.

Greece recently made several significant changes to its support scheme for renewable electricity generation to increase the rate of deployment and ensure low electricity prices. The current system provides subsidies that are awarded through competitive auctions and reflect market prices. Greece is also taking steps to reduce the time needed for licensing, permitting and connecting renewable projects to the grid. Since the Russian invasion of Ukraine, Greece has notably increased efforts to deploy renewables as a key part of

[2] Shares are based on Eurostat methodologies used to track progress on renewable energy targets and are different from the IEA methodology. Eurostat applies formulas to normalise fluctuations in wind and hydro generation, and uses multiplication factors that give higher shares to advanced transportation biofuels and renewable electricity in transport.

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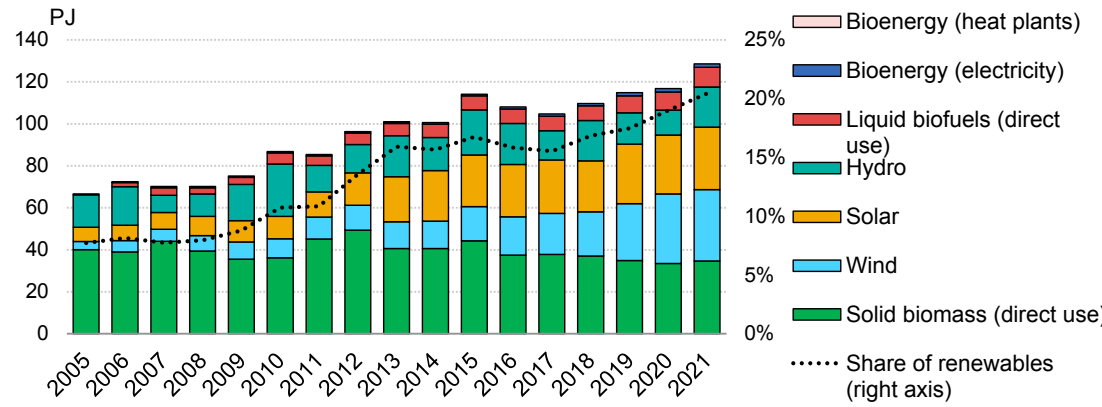
reducing reliance on Russian energy. In the longer term, Greece aims to be a net exporter of renewable electricity to the rest of Europe.

Figure 4.1 Renewable energy in total final energy consumption in Greece, 2005-2021



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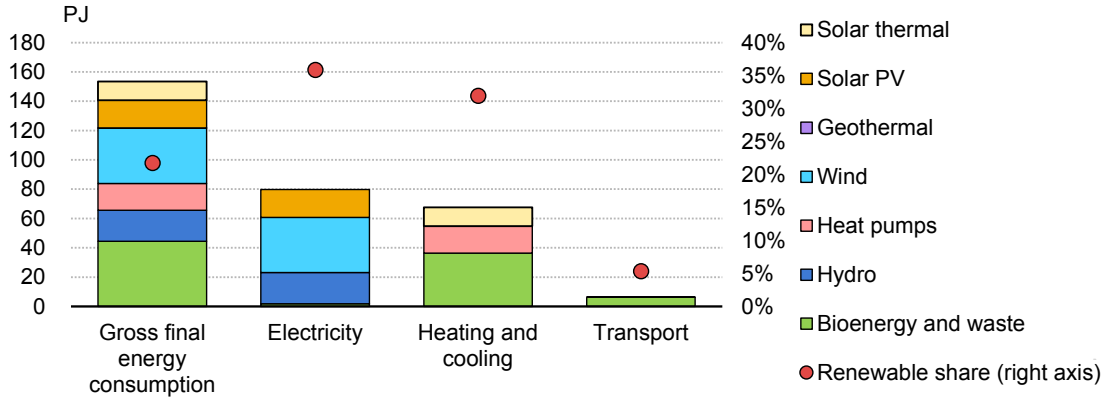
Source: IEA (2022).

Figure 4.2 Renewable energy in key metrics in Greece, 2021



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Sources: EC (2022a); IEA (2022).

Renewable energy targets

Under the EU Renewable Energy Directive, Greece has 2020 and 2030 targets for renewables in gross final consumption and electricity generation, heating and cooling, and transport, which are intended to support the achievement of EU-wide targets for renewables in gross final consumption to reach 20% by 2020 and 35% by 2030 (the 2030 target is likely to be increased to 45%). Greece's 2020 targets and supporting measures are set in its National Renewable Energy Action Plan. The 2030 targets and supporting measures are set in its NECP (Figure 4.3).

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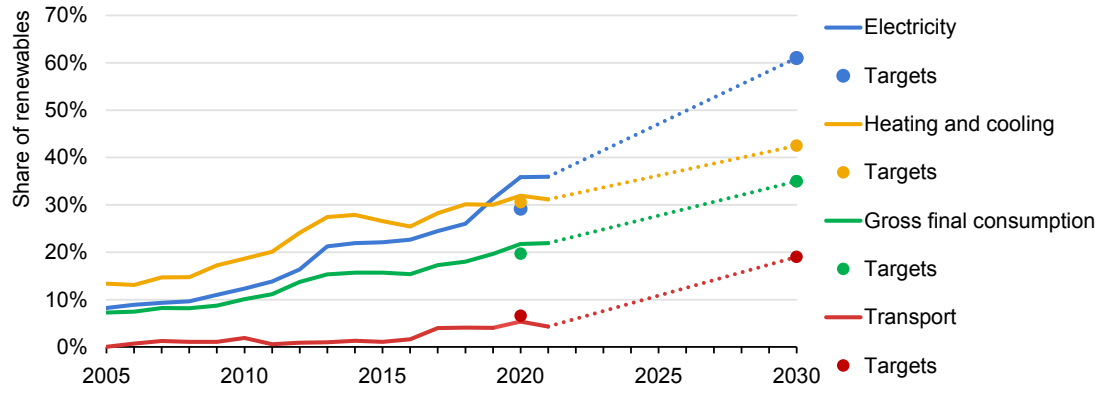
Figure 4.3 Greece's renewable energy targets and status, 2005-2021



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	Status	Targets and trajectories	
Renewable energy share	**2021**	**2020**	**2030**
Gross final energy consumption	21.9%	20%	35%
Electricity	35.9%	29.2%	61%
Heating and cooling	31.2%	30.6%	43%
Transport	4.3%	6.6%	19%

Source: IEA based on data from EC (2022a).

Greece overachieved its 2020 targets for renewable energy in gross final energy consumption, electricity generation, and heating and cooling. However, the achievement of these targets partly resulted from the significant reduction in energy demand caused by Greece's prolonged economic contraction and the Covid-19 pandemic. The government expects that energy demand will increase with economic recovery. Increased energy demand will require a faster pace of renewables deployment than seen in the last years to ensure the share of renewables increases in line with 2030 targets. This is especially true for the transport sector, where Greece did not achieve the 2020 renewables target.

In October 2020, the European Commission published its review of Greece's NECP, noting that the 2030 target for renewables in gross final energy consumption exceeds the needed contribution to the EU-wide target. However, in December 2020, the 2030 EU-wide GHG emissions reduction target was increased from 40% to 55%. To support the increased target and the REPowerEU efforts to end reliance on Russian energy, the European Union is updating numerous policies through the Fit-for-55 package. This includes significant changes to the Renewable Energy Directive, with a proposal to increase the EU-wide 2030 target for renewable energy in gross final energy consumption from 32% to 45%. Greece will likely need to increase its 2030 renewable energy targets to support the achievement of these more ambitious EU targets.

Renewable energy policy and measures

To achieve its 2030 renewable energy targets and place the country on a path to net zero emissions, Greece's renewable energy policy focuses on increasing electricity generation from renewables, mainly wind and solar PV, and electrification of energy demand, especially in building heating and transport. In addition to increasing the use of renewable electricity, Greece aims to continue the deployment of solar thermal heating, increase the

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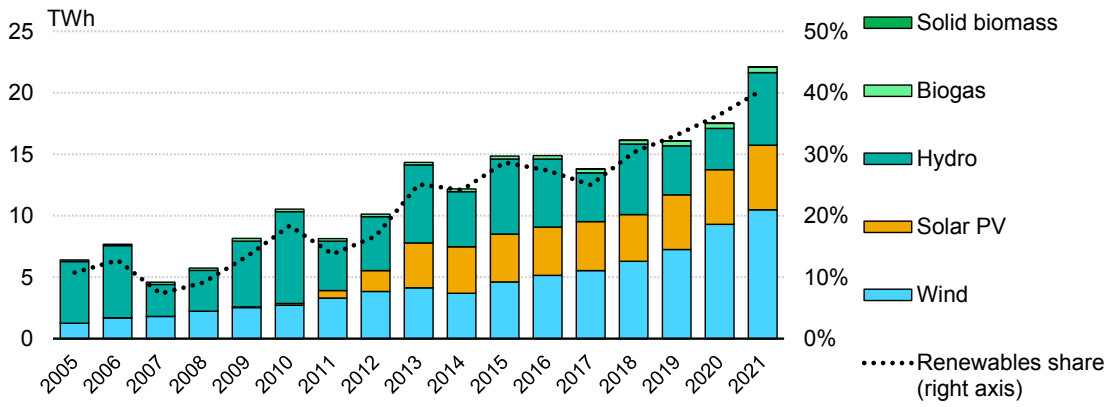
deployment of heat pumps and expand the use of transport biofuels, especially advanced biofuels. There are also general goals to use hydrogen produced from renewable energy in hard-to-decarbonise sectors such as shipping and heavy industry.

Renewables in electricity

From 2011 to 2021, Greece experienced an overall increase in renewable electricity generation, from 8.1 TWh to 22 TWh (Figure 4.4). Most of this growth came from a relatively steady increase in wind generation (3.3 TWh to 10.5 TWh). Solar PV grew significantly from just 0.6 TWh in 2011 to 3.7 TWh in 2013, but since 2014 has seen much slower growth, reaching 5.1 TWh in 2021. Hydro generation is highly variable depending on water availability, reaching a historic peak of 7.5 TWh in 2010. Because of continuing trends of lower precipitation, generation from hydro has been falling and was just 5.9 TWh in 2021. Generation from biogas is small, but increased from 0.2 TWh to 0.5 TWh between 2011 and 2021. In October 2022, renewable generation covered 100% of Greece's electricity demand for around five hours; this is the first time renewables have covered 100% of electricity demand.

Figure 4.4 Renewable energy in electricity generation in Greece, 2005-2021



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Source: IEA (2022).

Greece is pushing for much higher generation from renewables. The NECP has a target to expand renewable capacity (excluding large hydro) to 19 GW by 2030 versus 9.87 GW in September 2022. The government estimates that by 2030 there will be significant additions of capacity for solar PV (+4.2 GW) and wind (+2.9 GW), along with notable additions for pumped hydro storage (+0.7 GW), biogas (+0.2 GW), and the introduction of small capacities of geothermal (0.1 GW) and concentrated solar thermal (0.1 GW). As of July 2021, around 4.3 GW of new renewable projects had binding terms for a grid connection, mainly wind (2.4 GW) and solar PV (1.8 GW). Another 15.6 GW of renewable projects have applied for grid connections, mainly wind (14.7 GW). In April 2022, Greece's largest to-date PV plant, a EUR 130 million project with 0.2 GW of capacity, was connected to the grid; it is expected to generate around 0.35 TWh per year (Liangou, 2022).

Greece has several support mechanisms to encourage the deployment of renewable electricity generation. Large hydropower plants are excluded from participation in most support schemes for renewable energy but receive significant support through Greece's capacity market (see Chapter 6). Support for wind, solar PV, small-scale hydro, bioenergy,

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geothermal and a variety of other technologies is provided through a feed-in tariff (FIT), a feed-in premium (FIP), contracts for differences, net metering and investment subsidies.

In 2015, Greece introduced a FIT as the main measure to drive renewables deployment. The FIT provides a subsidy (EUR/MWh) for generation delivered to the grid and was initially open to most renewable energy technologies and project sizes (MW). The level and duration of FIT payments depend on several factors. Eligibility for the FIT has been progressively restricted, and it now primarily supports smaller scale or innovative renewable energy projects. Greece is transitioning to a system where most renewable energy support is provided through competitive auctions which award subsidies through a two-way contract for difference that accounts for market prices.

The Special Account for Renewable Energy Sources is the main funding source for renewable energy subsidies. The account is funded with revenues from the Special Duty of Greenhouse Gas Emissions Reduction, which is charged to all electricity consumers; from ETS allowance auction revenues; and from excess revenues earned by renewable suppliers receiving support through the FIP (RAE, 2022). Several recent policy and market changes have notably impacted the revenue going to the account. Authority over setting the Special Duty of Greenhouse Gas Emissions Reduction was temporarily moved from the RAE to the Ministry of Environment and Energy in 2019 and 2020. In 2019, the duty was reduced from 23 EUR/MWh to 17 EUR/MWh and set at this level through 2028.

Prior to 2021, most ETS allowance revenues (up to 78%) went to the Special Account for Renewable Energy Sources. Starting in 2021, most ETS allowance revenues (around 75%) were instead directed to the Energy Transition Fund, which provides subsidies to electricity consumers to reduce the impact of high energy prices. Since late 2021, high electricity prices have increased the revenue flowing into the Special Account for Renewable Energy Sources from the excess revenues earned by renewable suppliers receiving support through the FIP. Excess earnings for November and December 2021 contributed EUR 936.5 million to the account. However, in 2022, EUR 1.1 billion was transferred from the Special Account for Renewable Energy Sources to the Energy Transition Fund.

The Greek recovery and resilience plan includes calls for reforms to ensure the financial sustainability of the Special Account for Renewable Energy Sources. To support this effort, Greece passed legislation in June 2022 to create a sub-account to support renewable energy projects commissioned after January 2021 and a sub-account to support energy storage with a FIP-based subsidy. Establishing the sub-account for new projects was a condition for the renewables account to receive EUR 202 million from the EU Recovery and Resilience Facility.

In addition to the subsidies for generation provided through the FIP and FIT, the government provides subsidies and tax breaks to cover investment costs for certain renewable electricity projects built by private enterprises or social co-operatives. Under the 2016 Development Law, subsidies and tax breaks are available for investments in small hydro plants; biomass co-generation plants; and projects for self-consumption of solar, wind, geothermal and biogas. There are minimal project costs ranging from EUR 50 000 for social co-operatives to EUR 500 000 for large enterprises. Subsidies can cover 30-65% of relevant investment costs depending on the size of the enterprise investing and the type of project (RES Legal, 2019a). In addition, qualifying projects are

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eligible for tax relief (RES Legal, 2019b). The Ministry of Economy and Development funds the investment subsidies and tax relief.

Greece has measures supporting building renovations that support both energy efficiency and the deployment of renewable generation and energy storage (see Chapter 3). The Climate Law includes a requirement that starting in 2023, most new and large buildings need to generate electricity onsite from renewable sources.

There are also major electricity market reforms underway in Greece, which are primarily intended to bring the country into the common European electricity market and implement a range of EU requirements. These rules also intend to support renewable generation and energy storage by allowing them to participate in all segments of the electricity market (see Chapter 6). To limit the impact of high energy prices, Greece introduced wholesale market price caps in July 2022 for electricity generation from lignite (214 EUR/MWh), large hydro (112 EUR/MWh) and other renewables (85 EUR/MWh).

Under REPowerEU and new rules for renewable energy published in May 2022, EU member states could be required to map suitable land and sea areas for renewable energy projects. These so-called designated renewables go-to areas avoid environmentally valuable areas. The European Commission has made available relevant datasets in the Energy and Industry Geography Lab online platform to support member states in identifying go-to areas.

Subsidy auctions and power purchase agreements

From 2018 to July 2020, five auctions awarded FIP support to 142 MW of solar PV projects and 472 MW of wind projects. Over the course of these auctions, the average bids for selected projects declined from 64 EUR/MWh to 50 EUR/MWh for PV and from 70 EUR/MWh to 56 EUR/MWh for wind. Technology-neutral auctions were held in 2019, 2020 and 2021 (with most awards going to PV). The 2021 auction showed a continuing price decline, with an average bid of 38 EUR/MWh. Wind projects with a capacity less than 3 MW and other renewable projects (including solar PV) with a capacity less than 0.5 MW were not required to participate in these auctions but received a FIT contract if approved for grid connection. As of December 2020, around 6.3 GW of projects were receiving support through a FIT and 1.7 GW of projects through a FIP.

In 2021, Greece made significant updates to the auction system to accelerate the pace of renewables deployment and increase the share of subsidies awarded through competitive auctions. The updated system aims to support the deployment of 4.2 GW of solar PV and wind from 2022 to 2025, with a budget of EUR 2.27 billion. If a minimum technology diversification is not achieved via joint solar PV and wind auctions, the government will consider technology-specific auctions (Aposporis, 2021). Under the new auction system, subsidies are awarded through a two-way contract for difference. If market prices are below the bid price, a project receives the difference as a subsidy. If market prices are above the bid price, a project pays the excess to the Special Account for Renewable Energy Sources. Some technologies and projects are exempted from the auctions and receive compensation based on technology-specific reference prices, which are regularly updated to reflect cost trends.

Under the updated system, Greece planned to conduct five auctions in 2022. The first auction was held in March 2022 for 600 MW. A second auction was held in September 2022 for 1 000 MW. Because of a lack of bids meeting competition requirements, the

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September auction awarded support to only 538 MW of projects (372 MW of solar PV and 166 MW of wind). The average solar PV bid was 47.98 EUR/MWh, and the average wind bid was 57.66 EUR/MWh. PPC (Greece's largest utility) won the largest share of support with 250 MW (all solar PV) (Tsagas, 2022a). The other auctions planned for 2022 included one for 600 MW (joint wind and PV), one for 100 MW (small PV up to 1 MW) and a 200 MW pilot auction (wind and solar PV with energy storage).

The government has announced that from 2023 to 2025, it will hold auctions awarding contracts for differences for the following categories: 1) wind projects from 60 kW to 6 MW; 2) wind projects over 6 MW; 3) solar PV projects up to 1 MW; 4) solar PV projects over 1 MW; 5) wind projects over 10 MW with storage of at least 20% of the maximum hourly generation; and 6) solar PV projects over 10 MW with storage of at least 20% of the maximum hourly produced energy. Starting in 2023, there are further limits on the technologies and projects that can receive support outside the auction system.

Greece is also seeing a notable increase in renewable energy projects being developed with no subsidies but through power purchase agreements and other long-term contracts. PPC has opened several bids for power purchase agreement-based solar PV projects, including a bid opened in May 2022 for a 191 MW solar PV project and a bid opened in August 2022 for a 550 MW solar PV project. These are part of PPC's plans to deploy 1.5 GW of renewables by 2023 and 5 GW by 2027 (Balkan Green Energy News, 2022).

Licensing and permitting

Renewable energy projects in Greece face significant barriers in the timely processing of licences and permits. Greece is taking a variety of steps to reduce these barriers. A first round of legislative changes to simplify and accelerate the licensing and permitting process was passed in May 2020. This law abolished the generation licence, which required a lengthy application process, replacing it with the generation certificate, which requires significantly less documentation and is applied to via an online platform run by the RAE, which must grant the certificate within 20 days if the application meets all the requirements. The certificate is valid for 25 years and may be renewed (MStR Law, 2020). In addition, the law shortened the time period for the RAE to issue environmental licences, extended the duration of environment licence validity from 10 to 15 years, reduced land-use restrictions for renewable projects and created shorter deadlines for several milestones in the licensing process (Global Legal Insights, 2023). Renewable project developers also faced problems securing bids in the renewable energy auctions, as only a limited number of bids are accepted, and numerous bids were being placed by speculators for resale to project developers. In November 2021, the cost required to participate in the renewable energy auction system was increased to 35 000 EUR/MW to prevent the hoarding of applications by speculators.

A second round of legislation passed in July 2022 aims to reduce the duration of the licensing process to 14 months and facilitate the granting of licences to 12 GW of renewable energy projects by 2030 (EY, 2022). The law eliminates the requirement to apply for a provisional grid connection offer; instead, projects apply directly for a final grid connection offer while at the same time submitting a required grid connection bond. The TSO/DSO must approve or reject the application for the gird connection offer within 2 months. The project developer then has 2 months to accept the offer or submit a request for alternative options to connect to the grid.

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Once a project developer accepts a grid connection offer, they must apply for an installation licence within certain time limits: 12 months for solar PV and onshore wind; 18 months for other renewables, co-generation or energy storage; and 24 months for projects requiring an undersea connection of two or more non-interconnected islands. The time limit can be extended by 12 months if the project developer pays a monthly fee of 1 000 EUR/MW. The TSO/DSO must issue an installation licence to qualifying projects within 20 days from the date of the application or the submission of any required clarifications. The installation licence is valid for three years but can be extended by an additional 12 months for a monthly payment of 1 000 EUR/MWh.

Once a project has an installation licence, it can sign a connection agreement with the TSO/DSO. Signing the connection agreement requires paying the TSO/DSO the cost of any required grid upgrades up to a maximum of EUR 250 000. Under the law, the connection agreement allows the TSO/DSO to curtail up to 5% of the annual generation of the project with no compensation to support the efficient operation of the system or connection of additional renewable projects. For curtailment over 5%, the TSO/DSO must provide compensation.

Once a renewable project has been completed and connected to the grid, the TSO/DSO has 20 days to send a team to the project site for a final inspection and 30 days to issue an operating permit that allows the project to start delivering electricity to the grid. The operation permit is valid for 20 years, with the possibility for renewal for an additional 20 years.

The law requires the creation of a unified Information System for the Licensing of Renewable Energy Sources Projects (“PSAPE”) to be operated by the One-Stop Service of the MoEE. The PSAPE serves as a single online platform for the entire licensing and permitting process and connects the information systems of relevant licensing authorities.

Grid connections

Renewable energy projects are also facing notable delays in being connected to the grid because of a lack of grid capacity. In 2020, 913 MW of new solar PV projects were installed, but by the end of 2020, only 459 MW of these projects were connected to the grid (Tsagas, 2021). The situation was similar in 2021, with 792 MW of new PV capacity installed but only 422 MW of connected to the grid at the end of the year (Tsagas, 2022b). Greece is trying to decrease grid congestion and accelerate the connection of renewable energy projects.

The TSO is planning at least EUR 150 million in investments to expand transmission system capacity by 2027 to support additional renewable generation. The DSO is planning at least EUR 300 million in similar investments. The recovery and resilience plan provides EUR 100 million in funding to upgrade the electricity network to reduce the waiting time for grid connections and improve overall grid performance.

The July 2022 law intends to decrease grid congestion, including by adjusting the capacity margins in congested areas and releasing grid capacity from existing plants that stop operating. Under the law, the TSO may stop accepting new grid connection applications for up to six months in areas where the grid no longer has sufficient capacity for new connections. The TSO must provide public notice at least 90 days before it stops accepting new applications.

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The law also requires the DSO to stop accepting applications for grid connection offers starting 1 September 2022 for all solar PV projects and 1 October 2022 for PV projects located in Western Macedonia, except if the application concerns net-metering or residential PV systems. The DSO is required to publish updates of the available grid capacity every three months. If an update shows that there is a limited number of pending applications in a specific area, the DSO must start accepting new applications for PV stations and grant grid connection offers for the relevant area under the limitations set out by the law.

In addition, the DSO will calculate the available connection capacity at each substation. Wherever additional margin is identified, it will be made available for renewable projects based on self-consumption or net metering up to 10 kilowatts.

The law also allows renewable energy project developers to construct private electricity grids (up to medium voltage) and to connect projects and consumers to these grids without a grid connection offer from the TSO/DSO. These grids must be operated and maintained by the renewable project developer and must be registered with the TSO and DSO (Zepos and Yannopoulos, 2022).

System flexibility

Greece is taking steps to improve grid flexibility to support more efficient grid operations and integrate higher shares of variable PV and wind. Key measures include a plan to progressively roll-out smart meters to most consumers by 2030, increasing support for energy storage and including demand side response (DSR) in balancing markets.

Greece has limited deployment of smart meters. However, the DSO has a plan for all consumers to have digital smart meters by 2030. As of 2021, 13 000 smart meters had been deployed at the medium voltage level and 70 000 at the low voltage level, mainly for consumers with high electricity demand. In July 2022, the DSO announced it was working to finalise a tender process to select companies to deploy up to 7.7 million smart meters, with plans for additional tenders as needed to complete the smart meter roll-out. The DSO estimates that 100 000 smart meters will be installed in 2022, 500 000 in 2023, and between 800 000 and 1 million each year from 2024 to 2030. The full smart meter roll-out is expected to cost around EUR 1 billion (see Chapter 6).

Historically, DSR has played a limited role in Greece's electricity system. From 2016 to 2022, the TSO ran auctions for an interruptible load service, under which large consumers (with at least 3 MW of demand) connected to the high- and medium-transmission system could receive fixed payments to reduce demand in situations when the market did not support system balancing. Greece aims for DSR to play a much larger role in supporting efficient grid operations and the integration of variable renewable generation. In July 2022, Greece launched a new platform supporting DSR participation in the electricity balancing market (which replaced the interruptible load service system). The platform allows the participation of consumers of all demand levels, with distributed DSR possible through the aggregation of at least 1 MW of DSR capacity (see Chapter 6).

The platform is already encouraging increased DSR participation. As of October 2022, the RAE approved several licences for companies to provide DSR in the balancing market, including large industry consumers PPC (1 000 MW), Optimus Energy (350 MW) and Forena (500 MW), and companies that aggregate DSR from numerous smaller consumers, MYTILINEOS (500 MW) and NRG (100 MW).

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Electricity storage already plays a notable role in Greece's electricity system and market, and there are plans to increase electricity storge capacity. As of June 2022, Greece had two large-scale pumped hydro storage facilities in operation: Thissavros (0.38 GW) and Sfikia (0.33 GW). At the end of 2021, the RAE had issued 181 licences for electricity storage projects, with a total capacity of 14.3 GW, including 14 pumped storage projects with a total capacity of 3 GW. The July 2022 law sets a goal for the deployment of 3.5 GW of energy storage (excluding large hydro) by 2030, a notable increase from the NECP target of 1.4 GW of storage by 2030. The recovery and resilience plan includes EUR 0.5 billion to support the deployment of 1.4 GW of electricity storage, including a new 0.68 GW pumped hydro storage facility at Amfilochia. Projects combining electricity storage with wind or solar PV are now eligible for subsidies through renewable energy auctions.

The July 2022 law clarifies and accelerates the licensing process for energy storage projects. It creates clear legal and regulatory definitions for energy storage, including options for stand-alone storage and storage incorporated with renewable generation. The law expands the potential revenue streams for storage projects by giving them the right to participate in the intraday and balancing markets (previously, storage was only allowed to participate in the day-ahead market). The law allows the TSO to deploy and operate energy storage with the approval of the MoEE (in which case the storage assets cannot participate in the market but only support grid operations) or if the RAE determines that there is a relevant need that cannot be met by third parties (see Chapter 6).

Greece has created a dedicated aid scheme for energy storage projects, approved by the European Commission in September 2022. It has an estimated budget of EUR 341 million to support the construction and operation of around 0.9 GW of electricity storage connected to the high-voltage grid. The measure will be partly funded by the European Union's Recovery and Resilience Facility. The scheme will award aid through a competitive auction, which must take place before the end of 2023. Selected projects should be completed by the end of 2025. The aid will be granted as an investment grant paid during the construction phase and ten years of annual support paid during project operations. The annual support will be based on submitted bids but can be reduced if the project has excess market revenues (EC, 2022b).

Offshore wind and PV

The government wants offshore wind to play a significant role in Greece's energy transition (Greece currently does not have any offshore wind generation). The recovery and resilience plan includes funding to develop the offshore wind planning process and regulatory framework. In August 2022, the Greek parliament approved the country's first Offshore Wind Law, which aims for 2 GW of offshore wind capacity by 2030. The law appoints the state-owned exploration company HHRM to lead site investigation, allocation and concession development and makes the electricity TSO responsible for providing the onshore and offshore grid infrastructure to support offshore wind deployment (Wind Europe, 2022).

Under the law, the MoEE will adopt a series of decrees to fully define offshore deployment locations and the process for selecting projects and awarding funding. As part of this work, the MoEE will commission environmental impact assessments to define broad offshore wind development areas and will then assign installation zones within these areas. These zones will be defined in consultation with key stakeholders, including the military, fisheries, the tourism industry and the public.

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Project developers will be able to apply for non-exclusive research permits for the broader offshore wind development areas to undertake resource assessments and seabed surveys. The first round of applications for these permits should take place from 2023 to 2024. Only developers with a research permit will be eligible to bid in offshore wind auctions, with the first auctions potentially taking place in 2025 or 2026. The government aims for the auctions to award a sliding FIP. Selected bidders will acquire an exclusive right to construct and operate an offshore wind farm in the auctioned zone. Given that most Greek waters have depths greater than 50 metres, much of the offshore wind development will need to use floating wind turbines. The government is working to secure financial support for offshore wind projects and has indicated that funds could come from the REPowerEU (Energypress, 2022b).

The July 2022 law also calls for the development of 10 floating offshore solar PV pilot projects with a capacity of 0.5-1 MW per project. These pilot projects are exempt from most licensing and permitting requirements and will be eligible for operation subsidies.

Small-scale renewables and energy communities

Since 2014, small-scale renewable projects (generally those with a capacity of less than 0.5 MW) have been eligible for net metering. A virtual net metering scheme was introduced in 2016 and updated in 2017; it allows for net metering of renewable generation that takes place at a different site than the electricity consumption (RES Legal, 2019c). As of October 2022, there were more than 5 000 net metering and virtual net metering installations in the interconnected electricity system with a total capacity of 170 MW.

Greece aims to increase the deployment of renewable energy through energy communities. In 2018, Greece passed legislation defining an energy community as a co-operative that promotes a solidarity-based economy and addresses energy poverty through energy self-sufficiency and improving energy efficiency. Energy communities must undertake certain activities, with options including energy provision services, energy management and storage, and the use of EVs. In 2021, 400 energy communities had been established in Greece. Energy communities were initially given some advantages in securing subsidies for renewable energy projects. Starting in 2022, energy communities have to compete for support like any other market player (REScoop.eu, 2021).

Renewables in heating and cooling

From 2010 to 2021, renewable heating and cooling increased from 50 PJ to 67.5 PJ and from 19% to 31.1% of total heating and cooling demand (Figure 4.5). This growth was driven mainly by increased use of heat pumps (3 PJ to 18.3 PJ) and some increase in solar thermal (10 PJ to 12.7 PJ) and biogas (0.1 PJ to 1.4 PJ). The use of solid biomass for heating and cooling declined from 45 PJ in 2011 to 34.7 PJ in 2021. However, solid biomass still accounts for the largest share of renewables in heating and cooling (51.4% in 2021), followed by heat pumps (27.1%), solar thermal (18.8%), and biogas (2.1%). Greece has the highest use of solar thermal heating in the IEA, as it covered 5% of demand in buildings, compared to the IEA average of 0.6%.

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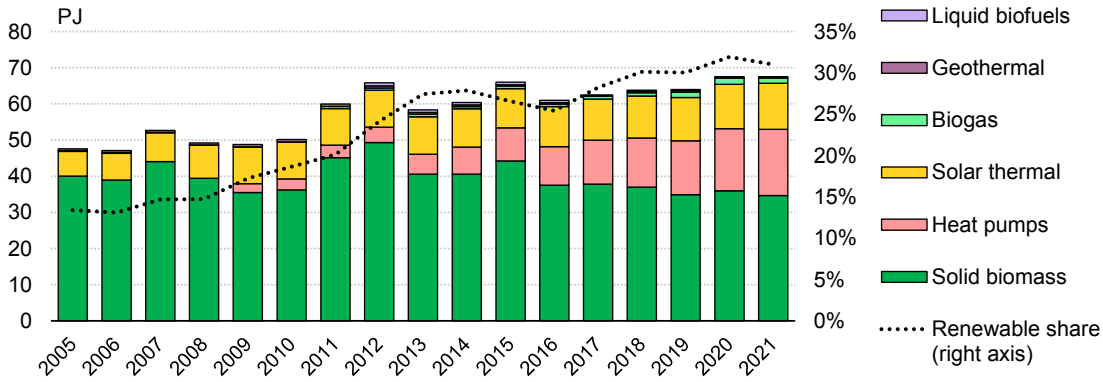
Figure 4.5 Renewable energy in heating and cooling in Greece, 2005-2021



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Source: EC (2022a).

Greece has several support measures that encourage the deployment of renewable heating and cooling systems. Since 2011, new buildings have been required to cover 60% of annual hot water demand using solar thermal. The requirement can also be met by using another renewable source, district heating, co-generation or heat pumps that meet minimum performance requirements. Greece provides an income tax deduction for investments in heating and cooling systems using solar thermal, biogas, biomass, geothermal and heat pumps (air, water and ground-source). The deduction is 10% of qualifying project costs up to a maximum of EUR 3 000 (RES Legal, 2019d).

There are also investment subsidies and tax credits for renewable heating and cooling projects built by private enterprises or social co-operatives. As stated above, under the 2016 Development Law, subsidies and tax breaks are available for investments in solar thermal, biogas, biomass, geothermal and heat pumps (air, water and ground-source). There are minimal project costs ranging from EUR 50 000 for social co-operatives to EUR 500 000 for large enterprises. Subsidies can cover 30-65% of relevant investment costs depending on the size of the enterprise investing and the type of project. The Ministry of Economy and Development funds the investment subsidies and tax relief (RES Legal, 2017).

Greece has measures supporting building renovations that entail both energy efficiency and the deployment of renewable heating and cooling systems (see Chapter 3). The government also aims to increase the share of renewable heating by injecting biomethane and/or hydrogen produced from renewable energy into the gas grid. There are no specific targets or support measures, and the government has indicated a need to develop various standards and regulations to allow grid injection of renewable gases. The government has expressed interest in developing a system of guarantees of origin for biomethane and hydrogen.

Renewables in transport

From 2011 to 2021, renewables in transport increased moderately, from 5.3 PJ to 8.6 PJ and from around 1% to 5.3% of total transport energy demand (Figure 4.6). Biodiesel accounted for the highest share of renewables in transport (64% in 2021), followed by biogasoline (33%) and renewable electricity (2%), mainly for rail.

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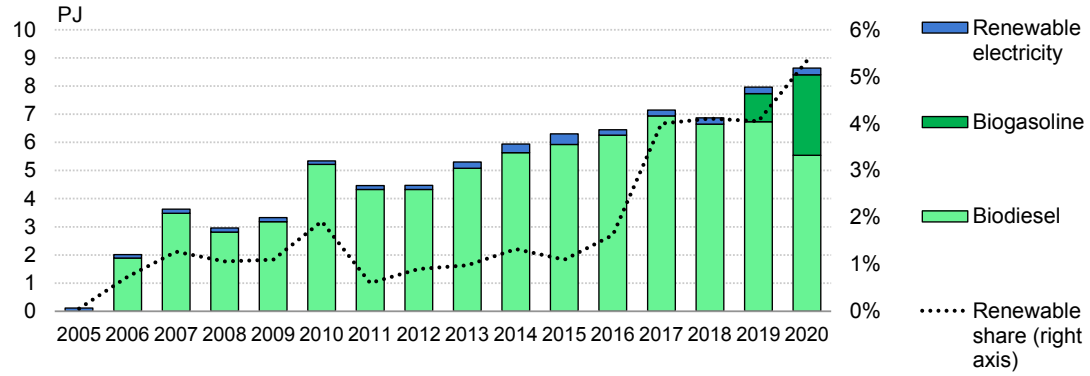
Figure 4.6 Renewable energy in transport in Greece, 2005-2020



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Sources: EC (2022a); IEA (2022).

Greece's main policy supporting renewables in transport is a biofuel blending mandate, which requires all producers and distributors of road transport fuels to have a certain share of biofuels in their annual fuel sales. The required shares are set annually by government decision. In 2017, the blending share of biodiesel in diesel (by volume) was increased from 5.75% to 7% and remained at this level through 2022. In 2019, the mandate was extended to require a 1% share of bioethanol or bioethers in gasoline (by energy content), with the share increasing to 3.3% in 2020 and no change through 2022. There is also an overall requirement that 0.2% of blended biofuels meet the EU standard for advanced biofuels. The government is assessing a potential increase in the required shares under the biofuel mandate.

From 2010 to 2020, domestic biodiesel production increased from 4.7 PJ to 6.6 PJ, with annual production often exceeding the level required under the biofuel blending mandate. There is no domestic production of ethanol as a transport biofuel.

Greece also aims to increase the use of renewable electricity in transport by supporting EVs. The NECP sets targets for EVs to account for at least 8.7% of new passenger car registrations by 2024 and 30% by 2030 (compared to 6.5% in 2021). Greece has a range of support measures to increase EV adoption, including direct subsidies and reduced taxes and registration fees (see Chapter 3). However, estimates on the level of renewables in transport from the NECP show that the government expects biofuels to remain the key option for meeting 2030 targets for renewables in transport (Table 4.1).

Table 4.1 Renewable energy in transport by type in Greece, 2020-2030

Renewables in transport (ktoe)	2020	2022	2025	2027	2030
Biofuels	9.5	10.0	11.8	12.0	15.5
Renewable electricity	0.2	0.5	1.1	1.9	3.9
Total	9.8	10.4	13.0	13.9	19.5

Note: ktoe = thousand tonnes of oil equivalent.

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Assessment

Renewables

To achieve the 2030 renewable energy targets and place the country on a path to net zero emissions, Greece's renewable energy policy places a strong focus on increasing electricity generation from renewables, mainly wind and solar PV, and electrification of energy demand. This pathway requires increased efforts in grid planning and operation to ensure that the electricity system can support a strong increase in both centralised and distributed renewable generation and deliver that generation to an increasing diversity of demand sources (EVs, heat pumps, high-demand industrial loads, etc.). It also requires co-ordination across the government to ensure that policies supporting the deployment of renewables are well aligned with those supporting electrification in a variety of end uses. Taking full advantage of this pathway will also require a completed roll-out of smart meters, digitalisation of grid infrastructure, increased demand side response and continuing development of electricity markets.

Renewables in electricity

In 2021, Greece made significant updates to its renewable support system to accelerate the pace of renewables deployment and increase the share of subsidies awarded through competitive auctions. The updated system aims to support the deployment of 4.2 GW of solar PV and wind from 2022 to 2025. Greece planned five auctions in 2022 to award support to 2.1 GW of projects. The government should use the results of these auctions to update the structure of the auctions as needed to ensure a sufficient number of high-quality bids. As long as grid congestion remains a barrier, the government should consider organising auctions only for locations where grid capacity is available for project connections.

The Special Account for Renewable Energy Sources is the main funding source for renewable energy subsidies. Several recent policy and market changes have notably impacted the revenue going to the account. In June 2022, reforms were adopted to ensure the financial sustainability of the account, creating sub-accounts for new renewable energy projects and energy storage projects. The government should ensure that the account is sufficiently funded in a transparent and sustainable manner to maintain investor confidence.

Renewable energy projects in Greece face significant barriers to licensing, permitting and connecting to the grid. Legislative changes to simplify and accelerate these processes were passed in May 2020 and July 2022, and aim to reduce the time from start to grid connection from five years to two years, the maximum limit allowed under EU regulations. The government should closely monitor the impacts of the recent reforms to ensure they lead to faster project deployment in a transparent manner, as the renewable industry has indicated that large complex fossil projects have been awarded licences in much shorter time frames than renewable projects.

The recent reforms do not address environmental licensing, which can lead to multi-year delays in starting projects. Environmental permitting can require numerous rounds of reviews and authorisation from multiple authorities, and by the time the awarding of the licence is close, the project is outdated and needs to start all over again with updated technology.

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Constraints on grid capacity also represent a major barrier to deploying renewables. Key measures to reduce this barrier include large investments by the TSO and DSO to expand capacity and improve the performance of the grid, a DSO plan to progressively roll-out smart meters to most consumers by 2030, regulatory changes and financial support for increasing energy storage, and inclusion of demand side response in the balancing market. The government should consult with the TSO and DSO to ensure that the upcoming grid investments target the most pressing bottlenecks in the electricity system and allow projects winning auction support to start construction quickly. Several stakeholders have indicated that the medium-voltage grid represents the main barrier to a near-term increase in renewables capacity. The planned large increase in renewables generation and DSR at low and medium voltage call for much stronger co-ordination on grid planning and operations between the TSO and DSO.

Curtailment of renewable generation is not an issue in the current system. However, already approved and planned projects could lead to a massive increase in the shares of wind and solar PV generation in the near term and could necessitate curtailment, especially if there are delays in developing grid infrastructure. Steps should be taken to limit inefficient curtailment. The RAE should update the network code and the rules for upcoming auctions to require new renewable projects to include remote monitoring and control features. Accelerating the deployment of energy storage would also help to reduce curtailment.

In addition, a more ambitious schedule for the roll-out of smart meters would assist with the accelerated deployment of distributed renewables and distributed DSR, helping to limit the cost of grid reinforcement.

Critically, the government should identify priority locations for the deployment of renewable generation projects that balance the quality of renewable resources, cost of grid expansion, environmental and cultural impacts, competing land uses and other key issues. This process should involve stakeholders early in the process. Impacted communities should benefit from nearby deployment through, for instance, tax revenues, profit sharing, investment opportunities or other means. The TSO and DSO should be involved so that projects developed in these areas can be guaranteed timely grid connections. The government should undertake initial environmental impact assessments for priority locations to support effective and timely environmental licensing.

The government wants offshore wind to play a significant role in Greece's energy transition. In August 2022, the Greek parliament approved the country's first Offshore Wind Law, which aims for 2 GW of offshore wind capacity by 2030. The government is working to secure financial support for offshore wind projects from EU funds. As with onshore renewables, the government should ensure that offshore wind is developed through a process that balances the many uses of Greece's marine areas and involves all stakeholders early in the process. Greece is also implementing major electricity market reforms, which include support for renewable generation and energy storage by allowing them to participate in all segments of the electricity market. This is an important step to increase market liquidity, as most new generation capacity is expected to come from renewables.

Increasing the participation of prosumers and energy communities is also critical to ensuring the deployment of distributed renewables on the scale desired by the government. This will require completing the smart meter roll-out, finalising rules on data

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access and security, and further developing the market structure (e.g. dynamic pricing) to ensure that consumers are driven to invest in distributed renewables. In the near term, the government should revise the existing net metering scheme so that consumers are incentivised to invest in renewables plus storage systems to allow for an expansion of renewable generation with a much lower impact on the distribution grids.

To shield consumers from high electricity costs, the government imposed caps on wholesale electricity prices in July 2022, including a cap of 85 EUR/MWh for renewable generation (see Chapter 6). There is a strong rationale behind market interventions to protect vulnerable customers from high energy prices. However, their impact must be monitored for potential harm to renewable developers' capacity to invest in new projects. Current and proposed market interventions in Europe could create uncertainties for renewable energy investments if they are not well designed or co-ordinated across countries. Moreover, the ongoing energy crisis has also sparked discussions in the European Union on possible changes to electricity market design. Any proposals must be carefully and transparently prepared, with clear visibility on timing and involve all relevant stakeholders to avoid unintended uncertainty among investors.

Renewables in heating and cooling

Greece has several support measures that encourage the deployment of renewable heating and cooling systems. Since 2011, new buildings are required to cover 60% of annual hot water demand using solar thermal, other renewable sources, district heating or heat pumps. There is a 10% income tax deduction, up to EUR 3 000, for investments in heating and cooling systems using solar thermal, biogas, biomass, geothermal or heat pumps. There are also investment subsidies and tax credits for renewable heating and cooling projects built by private enterprises or social co-operatives.

Greece is a global leader in solar thermal, which covered 5% of building energy demand in 2020, compared to the IEA average of just 0.6%. However, the share of demand covered by solar thermal has increased only marginally in recent years. The government should update policy support for solar thermal and increase research and innovation funding for solar thermal collectors combined with thermal storage to allow this technology to play a greater role in meeting heating demand and ensure Greece maintains a competitive advantage and export potential of this domestic industry.

Greece should ensure that energy efficiency programmes for buildings support deep renovations that combine thermal insulation with renewable heating and cooling systems. This helps to ensure that heating and cooling systems are properly sized and can deliver cost-effective reductions in emissions and energy bills. Preference should be given to systems that combine solar PV and heat pumps to minimise the impact on the grid. A priority should be placed on buildings with the worst energy efficiency and those occupied by vulnerable consumers.

Greece should consider introducing rules ensuring that heat pump and air conditioning systems and other electric heating and cooling systems allow for remote control. This will ensure that these assets can support distributed DSR in the future when smart meters and digitalisation are more developed and would greatly help to increase the role of distributed DSR in supporting efficient grid operation and integration of renewable energy.

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Renewables in transport

Greece's main policy supporting renewables in transport is a biofuel blending mandate. The government sets required shares annually, which were 7% for diesel and 3.3% for gasoline in 2022. There is also an overall requirement that 0.2% of blended biofuels meet the EU standard for advanced biofuels. The government is assessing potential increases in the required shares under the biofuel mandate.

Greece also aims to increase the use of renewable electricity in transport by supporting the adoption of EVs with direct subsidies, reduced taxes and registration fees, and investment in EV charging infrastructure. The NECP has targets for EVs to account for at least 10.1% of new passenger car registrations by 2024 and 30% by 2030 (compared to 7.9% in 2022). There is also a focus on electrifying high-use vehicles, such as taxis and public buses. The government needs to closely monitor the development of Greece's EV market and be ready to adjust policies to ensure growth continues. Close co-ordination is needed between the government, the electricity TSO and the DSO to ensure that grid development plans support the increased EV charging infrastructure needed to ensure EV uptake. Pilot projects should be run to determine the best solutions for the Greek system.

Greece faces a large challenge in meeting the 2030 target of 19% renewables in transport. The government needs to develop pathways to the 2030 target that clearly identify the needed level of biofuels, renewable fuels, EVs, charging infrastructure, grid investments and renewable generation. There should also be annual milestones for the shares of renewables in transport, and support mechanisms should be regularly evaluated and updated as needed to ensure the rapid growth required to meet the 2030 target.

In addition, the old age of the car fleet (average 16.6 years) results in high emissions and also limits the use of biogasoline, as many older cars cannot run on a blend with more than 5% ethanol. Measures need to be taken to permanently remove older cars from the roads to improve efficiency, reduce emissions and support higher shares of bioethanol. The government should consider a cash-for-clunkers programme that scraps older cars and provides subsidies for purchasing new efficient vehicles, including EVs.

Recommendations

The government of Greece should:

- Consult with the transmission and distribution system operators to ensure that the upcoming grid investments focus on the most pressing bottlenecks in the electricity system to ensure timely connection of projects with grid connections licences and the at least 4 GW of new projects expected by 2025.
- Work with communities and electricity sector stakeholders to develop priority areas for renewable energy deployment to ensure quick licensing and grid connections while balancing resource quality, grid costs, environmental and cultural issues, and land uses.
- Quickly implement the PSAPE one-stop shop and monitor its performance to ensure it efficiently supports all licensing processes.

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- Co-ordinate measures driving the deployment of renewable generation and electrification of end uses and ensure coherence with the expansion of the electricity system.

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5. Energy research and development

Key data

(2020)

Government energy research, development and deployment budget: EUR 1.46 billion

Energy R&D spending as share of GDP: 1.7 per 1 000 GDP units (IEA median: 0.34)*

Energy R&D spending per capita (2020): 2.8 EUR/capita (IEA median:* 13.5 EUR/capita)

* Median of 27 IEA member countries for which 2020 data are available.

Overview

The government sees energy research and development (R&D) as important to achieving 2030 climate targets and the long-term net zero emissions goal. No special policy document or strategy focuses on energy R&D, but energy R&D is important in the overall R&D policy setting. The NECP calls for the gross domestic expenditure on energy R&D to reach 0.13% of GDP by 2030, compared to 0.06% in 2017. The NECP provides an overview of research areas the government thinks are most critical to achieving energy and climate goals. These include new technologies for renewable electricity generation; electricity transmission, distribution and storage; heating and cooling; energy efficiency in buildings and industry; low-cost smart electromobility; advanced biofuels; and GHG reductions through low-emission technologies in industry, including CCUS.

Government funding (particularly from the European Union) and R&D conducted by public entities are the dominant drivers of Greece's R&D system. From 2012 to 2020, public spending for R&D grew from EUR 0.73 billion to EUR 1.46 billion, with energy- and climate-related R&D increasing from EUR 0.12 billion to EUR 0.47 billion. Although business R&D intensity more than doubled from 2010 to 2019, Greece's innovation system is still not business-driven. The government largely sets the direction of R&D efforts, and universities and public research institutes are the main entities performing R&D. Greece's universities and public research institutes produce high-quality research, reflected in the high and rising citation of their work (above EU and OECD averages since 2013).

Greece has a long history of scientific excellence, concentrated in a small number of public institutions, but it underperforms compared to its EU peers in terms of starting new energy technology companies and exporting new energy technology products. The European Union conducts an annual European Innovation Scoreboard to assess member states' research and innovation performance and the relative strengths and weaknesses of their research and innovation systems. The 2022 scoreboard indicated that Greece had one of the greatest improvements in performance on innovation among EU member states since

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2015 but it is still ranked in the moderate innovators group, indicating a performance below the EU average (EC, 2022a). The EU Eco-innovation Index measures EU member states' performance on environmental innovation, with the 2021 index ranking Greece as average for eco-innovation (EC, 2022b).

Energy innovation priorities and guiding documents

Government priorities for energy R&D through 2030 are defined in the NECP (adopted in 2019) and the National Research and Innovation Strategy for Smart Specialization 2014-2020 (adopted in 2015). The NECP indicates that research and innovation related to energy efficiency should focus on new building materials, like prefabricated active roof and facade elements; cost-effective, intelligent and flexible heat pumps; high-temperature heat pumps; and digitalisation and operational optimisation. The NECP calls for industry-related R&D to be focused on energy-efficient heating and cooling, heat and refrigeration recovery and integration of systems. In relation to renewable energy R&D, the NECP identifies the following focus areas: solar thermal energy for electricity generation, heating and cooling, bioenergy (biosolids, bioliquids, biogases and bioenergy intermediates), offshore wind and small wind turbines, solar PV, and deep geothermal energy.

The NECP states that the main R&D actions for electricity grids are smart grid services; better grid monitoring and control; demand response and control to optimise grid performance and reduce operational costs; solutions to increase electricity generation flexibility; reducing the cost of energy storage; and more integration of distributed renewable generation. The NECP states that transport R&D should focus on reducing the cost and improving the performance of EVs and charging infrastructure, and on developing advanced liquid and gaseous biofuels. It also notes R&D goals for the production of renewable hydrogen from electrolysis, increasing the efficiency of LNG storage facilities, and developing improved electricity or thermal energy storage technologies.

The NECP indicates that increased spending on energy R&D is needed, but it does not define binding targets or specify which funding mechanism or R&D entities should drive increased spending on energy R&D in the priority areas.

Greece is finalising a smart specialisation strategy for 2021 to 2027 which provides a framework for innovation investments that leverage Greece's R&D strengths and contribute to economic development. The strategy was developed through an entrepreneurial discovery process with participation from academia, industry, public authorities and civil society to identify the most promising innovation activities and corresponding technological needs. Based on this process, the strategy defines eight critical research areas and related policy tools: 1) agriculture and food; 2) health and biosciences; 3) information and communications technology; 4) energy; 5) environment and sustainable development; 6) transport and logistics; 7) materials and construction; and 8) tourism, culture and creative industries (EC, 2020).

Greece has a hybrid smart specialisation strategy, with a centrally administered national strategy (overseen by the General Secretariat for Research and Technology) and 13 regional strategies (overseen by regional authorities and co-ordinated by the Ministry of Development). As of February 2022, 8 of the 13 regions had identified sustainable energy as a main sector that can drive the desired transformation of the local economy.

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Key actors in the energy technology innovation ecosystem

The overall direction of the energy innovation ecosystem is driven mainly by the national government, which is the source of most energy R&D funding (primarily from EU sources), and by Greece's universities and public research institutes, which are the main entities performing energy R&D and which provide guidance to the government on energy R&D policy. However, more recently, the private sector has adopted a higher profile role through increased spending on energy R&D and more co-operation with universities and public research institutes.

The National Council for Research, Technology and Innovation is the supreme advisory body for national policy on research, technology and innovation. The council is appointed by and reports to the Minister of Education, Research and Religious Affairs. The council's Secretariat is provided by the General Secretariat for Research and Innovation (GSRI) (Esetek, 2022).

The GSRI is the main government body responsible for designing and implementing R&D policy (including for energy R&D). It runs the main public R&D funding programme (a competitive tender process), supervises and funds Greece's main research and technological centres, and is authorised to establish new institutes and technological centres. It promotes the transfer of advanced technologies and research findings to the private sector and contributes to increasing Greece's R&D human capacity. The GSRI supports Greek research entities in securing EU funding and promotes R&D co-operation with other countries and international organisations (GSRI, 2022).

The Hellenic Foundation for Research & Innovation, established in 2016, is a non-profit entity that funds R&D programmes and scholarships. Beneficiaries can be Greek universities, research centres or technological institutes. The Hellenic Foundation for Research & Innovation's budget for 2016 to 2020 was EUR 240 million, provided by the European Investment Bank (EUR 180 million) and the Greek Public Investments Program (EUR 60 million). The foundation is financially independent but supervised by the Ministry of Education, Research and Religious Affairs. The Hellenic Foundation for Research & Innovation's leadership is appointed by Greece's academic and research community and, in contrast to the GSRI, the foundation uses a bottom-up approach to define funding priorities (HFRI, 2022).

Resource push[3]

Public spending on R&D

From 2012 to 2020, Greece notably increased public spending on overall R&D, which grew from EUR 0.73 billion to EUR 1.46 billion, with energy- and climate-related R&D (industry,

[3] This and the following sections are structured according to the IEA framework for energy innovation policies. Technology innovation processes are complex and decision makers must pay attention to a variety of elements. The IEA groups these elements into four core functions: A) resource push; B) knowledge management; C) market pull; and D) socio-political support. Successful energy innovation ecosystems have effective policies in each of the four areas. In some cases, the policies might operate at different levels, such as local, national or municipal. See: https://www.iea.org/reports/tracking-clean-energy-innovation

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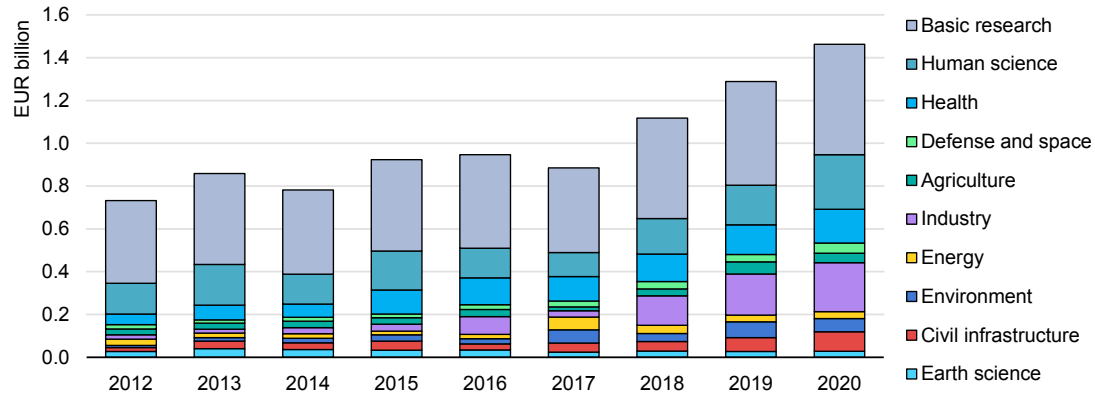
energy, environment, civil infrastructure and earth sciences) growing from around EUR 0.12 billion to EUR 0.47 billion (Figure 5.1). The government indicates that spending on overall R&D increased from 1.28% of GDP in 2019 to 1.5% in 2020. Most public R&D funding goes to public research entities. In 2019, Greece had one of the lowest shares of government support to private sector R&D as a percentage of GDP (just 0.05%). As an EU member state, Greece is committed to supporting the 2030 target for EU-wide spending on overall R&D to reach 3% of EU-wide GDP by 2030, compared to 2.2% in 2018.

Figure 5.1 R&D public spending by sector in Greece, 2012-2020



Note: Excludes public funding coming directly from the European Union to RD&D entities in Greece.
Source: OECD (2022).

The government's main public R&D funding programme is a system of competitive calls for proposals organised by the GSRI. The GSRI selects R&D topics based on government priorities, and funding is awarded through peer review. Greece's recovery and resilience plan (funded by the European Union) includes EUR 0.3 billion for energy R&D relating to EVs and the development of Greece's first CO_2 storage facility.

Most of Greece's public R&D funding (including energy R&D) is financed by EU programmes. A substantial share of Greece's public R&D funding is awarded directly by the European Union through the Framework Programme for Rresearch and Innovation, the European Union's main mechanism for directing innovation funding to member states. Horizon 2020, the European Union's funding programme for research and innovation from 2014 to 2020, provided EUR 80 billion for R&D through a competitive process open to all EU public and private R&D entities and was designed to increase public and private partnerships as well as international co-operation. Horizon 2020 provided a total of EUR 1.7 billion of R&D funding in Greece, with EUR 0.48 billion going to energy- and climate-related R&D, including EUR 147 million for advanced manufacturing and processing, and advanced materials; EUR 147 million for secure, clean and efficient energy; and EUR 112 million for climate action, environment, resource efficiency and raw materials (EU, 2022a).

Horizon Europe, the EU research and innovation framework programme for 2021 to 2027, was launched in February 2021. It aims to provide around EUR 100 billion in R&D funding, will continue to support energy-related R&D and sets goals to increase international R&D co-operation (EC, 2022c). The GSRI organised a national launch event for Horizon Europe in Greece in June 2021, and Horizon Europe funding started being delivered in 2022. As

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of March 2023, Horizon Europe had delivered around EUR 645 million in funding to Greece, with EUR 136 million going to the thematic priority of climate, energy and mobility and EUR 80.1 million going to the thematic priority of food, bioeconomy, natural resources, agriculture and environment (EU, 2022a).

Greece also supports R&D by allowing companies to deduct relevant R&D expenses from their tax liability. From 2010 to 2019, the cost of tax relief for R&D increased from EUR 6 million to EUR 14 million. In September 2020, Greece updated its tax deduction system for R&D expenses with the goal of increasing R&D investments, especially in the private sector.

Under the new system, companies can deduct 100% of qualifying R&D expenses from their tax liability in the same year the investments are made. If the deduction exceeds annual tax liability, it can be carried forward to reduce tax liability up to five years after the expenditures were made. The system was also updated to reduce the requirements and waiting time to process tax deduction applications. Companies can now submit the required documentation for R&D expenses to the GSRI with an audit report signed by a certified auditor and/or auditing firm that certifies the realisation of such expenses and their amount. The GSRI focuses solely on whether the realised expenses actually relate to R&D activities; it does not proceed to a full-scope review. The GSRI must complete the process within six months, or the respective R&D expenses are automatically approved (OECD, 2021).

Support to start-ups and entrepreneurs

The government aims to support energy start-ups and entrepreneurs through increased co-operation and knowledge transfer from public R&D entities and the private sector. A national survey published in 2019 (based on data from 2014 to 2016) indicated that a comparatively high share (18%) of innovating firms collaborated with universities and public research institutes (EKT, 2019).

Greek companies receive support for R&D through the Business Innovation Greece Programme run by the EEA Grants and Norway Grants Programme (supported by Norway, Iceland and Liechtenstein). The Business Innovation Greece Programme seeks to stimulate and develop long-term business co-operation between Iceland, Liechtenstein, Norway and Greece based on business development and innovation. The programme aims to allocate 75% of the funding to SMEs, with priority to be given to bilateral partnerships. The programme has a total budget of EUR 21.5 million directed to three focus areas: 1) green industry innovation (40%); 2) blue growth (40%); and 3) ICT (20%).

Private spending on energy R&D

There is limited data collection on private R&D spending in Greece. OECD data show that business R&D intensity (R&D spending over revenue) in Greece increased from 0.24% to 0.59% from 2010 to 2019 (OECD, 2021). The EU Community Innovation Survey, an annual survey sent to private companies across the European Union, indicates a high and increasing level of private sector innovation activities in Greece. The most recent survey covers 2018 and showed that 60% of Greek companies funded innovation activities that year. This was the ninth-highest share among EU member states and an increase compared to 57% in 2017 (EC, 2021).

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Greek companies can participate in the R&D tenders run by the GSRI; however, most of this funding goes to public research entities.

Knowledge management

International co-operation

IEA technology collaboration programmes (TCPs) are multilateral mechanisms that support global collaboration to advance co-operation on research and the use of specific energy technologies. The TCPs are composed of thousands of experts across government, academia and industry in 55 countries that co-operate on 38 technology-specific programmes. Experts can be officially appointed by governments or join privately from industry and research entities. Since the IEA's last Energy Policy Review in 2017, Greece has ended its participation in five TCPs (energy technology systems analysis, fluidised bed conversion, concentrated solar power, hydrogen, and wind energy). The GSRI intends to renew Greece's participation in the Hydrogen TCP.

Mission Innovation is a global partnership of 23 countries and the European Commission that aims to accelerate clean energy innovation. As an EU member, Greece participates with Australia, Chile, the United Kingdom and the United States in the Mission Innovation Clean Hydrogen programme, which aims to make low-carbon hydrogen cost-competitive by 2030. Greece does not participate in the Clean Energy Ministerial, a high-level global forum that promotes policies and programmes to advance the deployment of clean energy technologies.

The GSRI is responsible for public sector co-operation with other countries on research and innovation. Existing collaborations cover a wide range of bilateral and multilateral actions, which vary from co-operation at ministerial level, including the Organization of the Black Sea Economic Cooperation, to collaborations by researchers/scientists, including through the EU ERANETS. The NECP notes a goal to increase the participation of Greek research centres in international partnerships, compared to the current practice of participating only in EU-financed programmes. To support increased international R&D co-operation, the GSRI is launching calls for proposals based on international collaboration on science and technology co-operation in the energy sector. The proposals involve areas of mutual interest in the energy sector, developed through consultations with the competent bodies of the partner countries.

Intellectual property

Despite the increased energy R&D spending, Greece has seen a reduction in energy- and climate-related patents. (Figure 5.2). This trend is partly explained by an exodus of skilled workers in the energy sector due to the country's prolonged economic crisis. Greece's patent application rate (number of patents per EUR billion GDP) was 0.8 in 2019 compared to 3.3 in the entire European Union (EU, 2022b). In 2019, 8% of patents in Greece were dedicated to energy-related technologies compared to 10% in the European Union.

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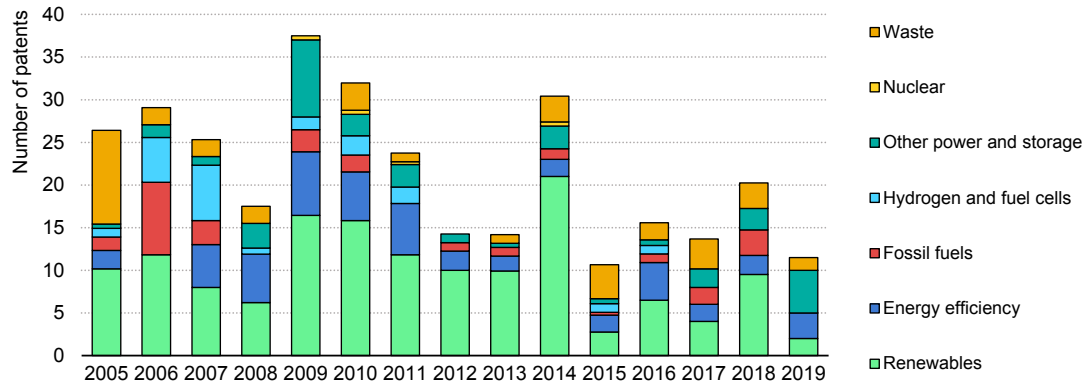
Figure 5.2 New patents in energy-related technologies in Greece, 2005-2019



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Source: EU (2022b).

Networks

Innovative Greeks is a network of experts that aims to scale up the Greek start-up ecosystem and improve access to international markets, increase innovation potential through synergies with international research facilities, attract tech-led investments in fast-growing industries, attract expertise and talent to Greek start-ups, improve Greece's appeal as a top investment and work destination, and inform about the achievements of the national innovation ecosystem. The network includes a group on Clean Tech/Energy Transition. The network for Greek start-ups aims to reach EUR 10 billion in capitalisation and create 50 000 jobs by 2025. Innovation Greek is an association of Greek SMEs (including several with activities in the energy sector) and a competitive ecosystem of high-calibre innovation-based SMEs.

Market pull

Energy R&D is also supported through subsidies that aim to deploy innovative and pilot renewable energy projects. These projects are eligible for financial support, including operation and investment subsidies, on the condition that they increase domestic added value and contribute to covering local or special energy needs (see Chapter 4).

Monitoring, evaluation and tracking of results

The GSRI has a mandate to evaluate the outcomes of the R&D projects that it funds and to use this information to adjust research policy. The GSRI also evaluates R&D projects funded through Horizon 2020 and Horizon Europe. The system of evaluation for the R&D conducted from 2014 to 2020 encompasses several phases. In the first phase, there was an *ex ante* evaluation of the proposals by external evaluators (peer review) following EU rules for Horizon 2020. The progress in R&D projects and their first results were evaluated using EU rules related to the smart specialisation strategy monitoring mechanism. A third phase will include an *ex post* evaluation of the final results of the R&D projects.

Greece's performance in R&D is also monitored and evaluated through the European Innovation Scoreboard. The 2022 scoreboard indicated that Greece had one of the

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greatest improvements in performance on innovation among EU member states since 2015 but is still ranked in the moderate innovators group, indicating performance below the EU average. The scoreboard noted relative strengths for product innovators, innovative SMEs collaborating with others, employment in innovative enterprises, sales of innovative products and business process innovators. Relative weaknesses were identified for the number of foreign doctorate students, lifelong learning, employed ICT specialists, government support for business R&D, and medium- and high-tech goods exports. In addition, the EU Eco-innovation Index measures EU member states' performance on environmental innovation. The 2021 index ranked Greece as average for eco-innovation.

Assessment

The Greek government sees energy technology innovation as important to achieving 2030 climate targets and the long-term net zero emissions goal. No special policy document or strategy focuses on energy R&D, but energy R&D is given an important role in the overall R&D policy setting. The government declared its intention to double gross domestic expenditure on energy R&D in the period 2017-2030 to reach 0.13% of GDP, compared to 0.06% in 2017.

Funding for energy R&D in Greece comes mainly from EU sources. From 2014 to 2020, Horizon 2020 contributed EUR 0.48 billion for energy R&D in Greece, with significant additional funds from other EU sources. During the period 2014-2020, the national "Research-Create-Innovate" programme dedicated EUR 6 million per year to the seven innovation streams related to energy and an additional EUR 1 million per year from the ERANets and bilateral co-operation programmes. The high share of R&D funding coming directly from the European Union reduces government leverage over the topics that are ultimately covered, which could create challenges in implementing a smart specialisation strategy.

There are very limited data on private spending in R&D in Greece. The available information from the OECD and the data from the national tax deduction system indicate a progressive increase in private sector innovation. The government has also recently taken steps to support the private sector and start-ups in driving increased energy R&D in Greece.

The continuous monitoring of expenditures in energy R&D, categorised by source, sector and recipient, should be a key instrument to ensure the development of the innovation process in the country and the adequate allocation of resources. Greece has not submitted data on energy-related R&D to the IEA since 2011.

The government should upgrade the existing inventory of public energy R&D projects and funding and publish this information on a transparent and regularly updated web portal. This information should be used to monitor spending and assess the achievement of the objectives of the National Research and Innovation Strategy. Data collection should be extended to private R&D activities (based on the OECD guidelines), and these data should be communicated to the IEA in a timely manner.

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Policy measures for R&D prioritisation

The priorities for energy R&D are set in the NECP and the Smart Specialisation Strategy, which includes regional strategies covering sustainable development, energy and transport. There is a lack of coherence across these strategic documents. Although an inclusive process is established for identifying priorities, the energy innovation ecosystem remains strongly driven by universities and public research centres that are also the main entities performing energy R&D. The business sector contributes little to defining R&D priorities because it is mainly focused on mature technology rather than on R&D and because of the low correlation between demand and supply of innovation from businesses and research institutions.

The government should streamline the strategy formulation process, thus limiting inefficiencies due to distributed and unclear responsibilities and avoiding inconsistencies. The inclusive process would be improved by establishing national platforms using the European Energy Technology and Innovation Platforms model, co-ordinated by the Ministry of Development. The participation of industrial stakeholders should be ensured, in proactive dialogue and co-operation with academia and public research institutions, to establish priorities, evaluate the needs and sharing of resources, and identify the most effective pathways for the exploitation and implementation of the R&D results.

Policy measures to foster R&D projects and achievements

The GSRI is the main government body responsible for implementing the R&D policy (including for energy). Analysis of the R&D funding for 2014-2020 shows a distribution of small amounts of funding across many projects. The average funding of projects under the "Research-Create-Innovate" programme is around EUR 180 000 per year per project. This limited level of funding can support desk research and small- to medium-scale laboratory or field activities but not large-scale industrial projects. Instead, Greek research centres and industrial parties prefer to carry out large demonstration projects to validate, under real conditions, smart solutions and innovative technologies.

The GSRI also has the mandate to evaluate the outcomes of R&D projects that it funds and to use this information to adjust research policy. The GSRI also evaluates R&D projects co-funded by the European Union. Although each project proposal is evaluated *ex ante* in terms of excellence, impact and quality of implementation by a group of experts, no evidence is given about monitoring ongoing projects, or *ex post* on their real achievements, impacts, contributions to reaching the R&D strategy, the knowledge they generate or the transfer to stakeholders, to transform it into innovative actionable outputs of potential interest for further development by businesses.

The government should ensure that the inventory of public and private R&D projects includes a mapping of the topics, technologies and solutions addressed and feedback to the energy R&D strategy. A process for monitoring the project development and an *ex post* assessment should be organised and implemented to ensure maximum impact and technology transfer to businesses, as well as potential market uptake.

Policy measures to accelerate market uptake

The quality of the research carried out by Greek universities and research centres is recognised internationally for its excellence.

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However, this level of excellence does not result in equivalent business development: the percentage of enterprises with product innovation remains lower than the EU average; innovative products do not contribute significantly to the total turnover of enterprises; the number of patents shows a decreasing trend and remains very limited (in the range of 10-20 per year) compared to R&D spending (patent application rate 0.8 patents per EUR billion GDP); a significant portion of skilled personnel migrates in search of better opportunities abroad.

The technology transfer offices of the public research centres should ensure closer collaboration between businesses and the R&D community, also facilitating the conduction of applied research and demonstration on the premises or in close collaboration with industries and businesses. Promising sectors for potential collaboration are the application of digital technologies and solutions and advanced data analytics. Transferring methods and tools from the research community to the business sector can also create new business opportunities. Energy retailers, for example, could largely benefit from the development of advanced data management of measures from smart meters.

The electricity network operators (TSO and DSO) also undertake R&D activities; however, they have small R&D departments with limited capacity. Greece's energy policy calls for a major reworking of the electricity system and significant operational changes. The government should support the network operators in conducting R&D, both on their own, in co-operation with domestic R&D entities and through participation in EU programmes. This could include forward-looking regulatory frameworks, adopting a more holistic view of innovation across the various stages, from early R&D programmes to innovation uptake, and using regulatory sandboxes.

International collaboration

Since the IEA's last Energy Policy Review in 2017, Greece has ended its participation in five IEA TCPs (energy technology systems analysis, fluidised bed conversion, concentrated solar power, hydrogen and wind energy). The GSRI intends to renew Greece's participation in the Hydrogen TCP. Through the European Union, Greece participates with Australia, Chile, the United Kingdom and the United States in the Mission Innovation Clean Hydrogen programme, which aims to make low-carbon hydrogen cost-competitive by 2030. The government should enhance the participation of Greek R&D entities in international collaboration on clean energy R&D, specifically with regard to IEA TCPs and Mission Innovation 2.0 initiatives, building on Greece's investment strategies for clean energy technology.

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Recommendations

The government of Greece should:

- Allocate binding budgets to each of the instruments selected to finance energy research and development for the period 2021-2027, taking into account the priorities of the National Research and Innovation Strategy. The budget sharing should be regularly re-evaluated depending on the evolution of energy policy priorities and emerging necessities.
- Revise the criteria for allocating funding to research and development projects to avoid splitting budgets into small amounts across many streams and reduce transaction costs. This will enhance the interest of industrial partners and increase the share of medium and large demonstration projects that receive support.
- Facilitate the transfer of knowledge from universities and public research centres to companies through measures to accelerate market uptake, including the use of open access principles, recourse to standardisation and implementation of continuous education programmes.

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6. Electricity

Key data

(2021)

Electricity generation: 55 TWh (natural gas 41%, wind 19%, hydro 11%, lignite 9.7%, solar 9.6%, oil 8.5%, bioenergy and waste 1.0%); -8% from 2011 to 2021

Electricity net imports: 3.7 TWh (imports 7.6 TWh, exports 3.9 TWh)

Electricity demand: 51 TWh (residential buildings 35%, service sector buildings 32%, industry 32%); -5% from 2011 to 2021

Peak load: 10.5 GW (August 2021)

Installed capacity: 20.4 GW (2022)

Import capacity: 2.4 GW (2022)

Overview

Greece's electricity sector is undergoing major changes. Recent and ongoing reforms aim to fully integrate the national electricity market into the common European market. Lignite-fired generation, once the dominant source of electricity, has been strongly reduced and will be phased out by 2028 at the latest. There have been rapid increases in generation from natural gas, wind and solar PV, significantly reducing the carbon intensity of generation.

The electricity sector plays a key role in Greece's energy policy. The government aims to reduce GHG emissions across the economy by increasing electricity generation from renewables (especially solar PV and wind) while boosting electrification of energy demand (especially for road transport and building heating and cooling). Greece also aims to support the integration of renewables and increased system flexibility through battery storage and DSR. The government also has a goal to interconnect all populated islands to the mainland grid by 2030 to end their reliance on oil-fired generation.

The government sees gas-fired generation as a key technology to compensate for the reduction in lignite-fired generation while maintaining dispatchable generation for system balancing. However, the role of gas is being re-evaluated following the Russian invasion of Ukraine and continued gas price volatility.

Electricity demand, generation and trade

Greece experienced an overall decline in electricity demand from 2011 to 2021, which fell from 54 TWh to 51 TWh (Figure 6.1). However, over this period, there were notable

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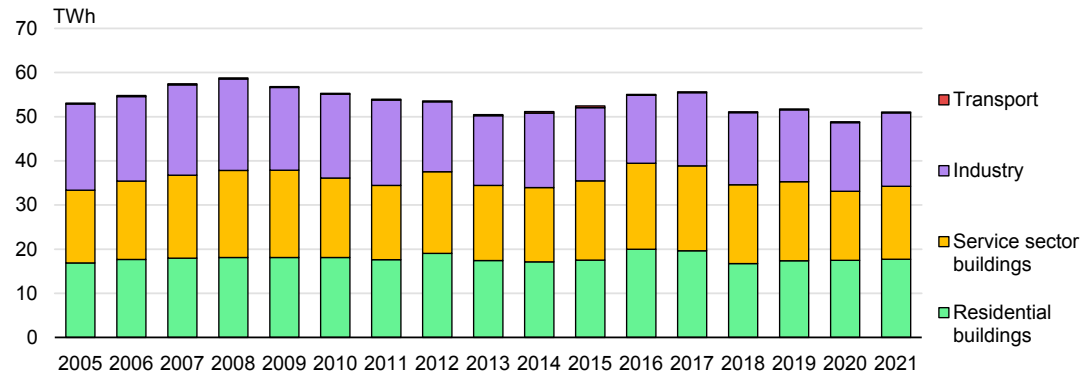
variations in electricity demand driven mainly by fluctuations in electricity demand from buildings, which ranged from a maximum of 39 TWh in 2016 to a minimum of 33 TWh in 2020. The variability of building demand is driven mainly by annual changes in heating and cooling demand. As a result of Greece's economic crisis, industry electricity demand dropped sharply from 21 TWh in 2008 to 16 TWh in 2012 and fluctuated slightly through 2021 when it was 17 TWh. Greece has only marginal electricity demand from the transport sector (0.2 TWh in 2021), which comes mainly from rail.

From 2010 to 2021, the share of total energy demand covered by electricity increased from 23% to 28% (compared to an IEA average of 22% in 2021). In 2021, electricity covered 50% of total energy demand from buildings: 36% for residential buildings and 83% for service sector buildings. In comparison, the average shares of electricity in energy demand from buildings among IEA member countries in 2021 were 44% (total), 39% (residential) and 52% (service). The high shares in Greece reflect a relatively higher use of air conditioning and the notable cooling demand, especially in the tourism industry. In contrast, very little building space heating in Greece is covered by electricity. Electricity covered the second-highest share of industry energy demand in 2021 (33%), compared to the average of 21% among IEA member countries. This reflects the relatively limited role of heavy industry in Greece.

Figure 6.1 Electricity demand by sector in Greece, 2005-2021



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Source: IEA (2022a).

From 2011 to 2021, electricity generation decreased from 59 TWh to 55 TWh and experienced a significant change in the resource mix (Figure 6.2). Over this period, lignite-fired generation dropped strongly from 31 TWh to 5.3 TWh. The reduction in lignite-fired generation has been covered by increased gas-fired generation (14 TWh to 22 TWh), higher renewable generation (8.1 TWh to 22 TWh) and increased electricity imports. Most growth in renewable generation came from increased wind generation (3.3 TWh to 10 TWh) and solar PV generation (0.6 TWh to 5.3 TWh). Hydro generation is highly variable depending on water availability, reaching a historic peak of 7.5 TWh in 2010. Because of continuing trends of lower precipitation, hydro generation has been falling and reached 5.9 TWh in 2021. There was also a small decrease in oil-fired generation (5.9 TWh to 4.7 TWh), used mainly in non-interconnected islands and replaced by interconnections to the mainland grid and renewables generation on the islands.

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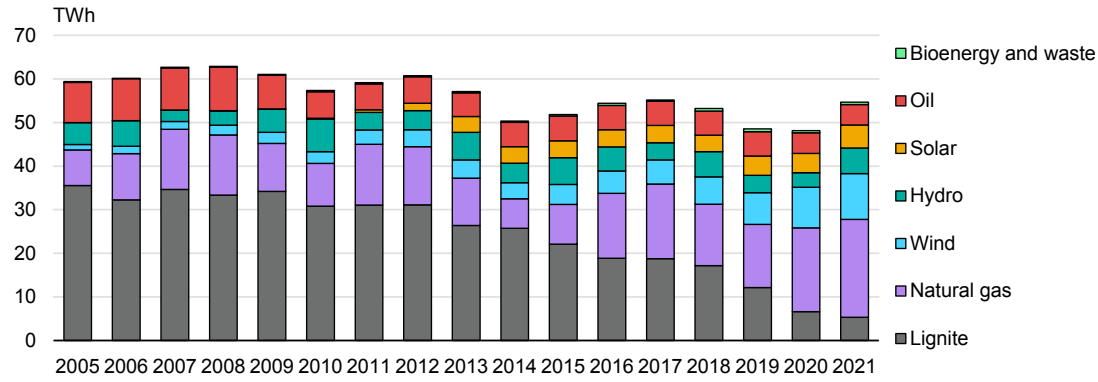
Figure 6.2 Electricity generation by source in Greece, 2005-2021



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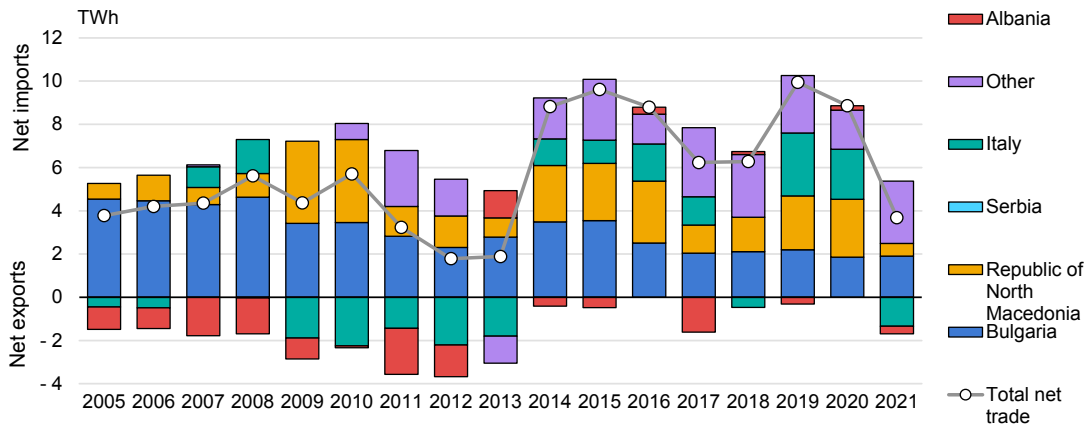
Source: IEA (2022b).

Greece is a net importer of electricity (Figure 6.3). Net imports have varied notably since 2010, ranging from a minimum of 1.8 TWh in 2012 to a maximum of 9.9 TWh in 2019. The variations in imports were driven mainly by economic conditions in Greece that affected electricity demand and market competition between domestic generation and imports; imports have increased as low-cost lignite generation declined. Greece is making substantial investments in electrical interconnections to support further integration with the European electricity system and aims to become a net electricity exporter by 2030.

Figure 6.3 Greece's electricity imports and exports, 2005-2021



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Source: IEA (2022b).

Infrastructure

Greece's electricity infrastructure consists of large thermal plants (natural gas and lignite) and renewable generation (large-scale hydro, wind and solar PV, and small-scale distributed generation, mainly solar PV), cross-border interconnections to Albania, Bulgaria, Italy, North Macedonia and the Republic of Türkiye (hereafter "Türkiye"), a transmission and distribution network that serves the mainland and interconnected islands, and numerous isolated distribution networks on non- interconnected islands (Figure 6.4)

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Figure 6.4 Major existing and planned electricity infrastructure in Greece, 2022

Installed generation capacity

From 2016 to 2022, Greece's installed generation capacity increased from 16.2 GW to 20.4 GW, excluding capacity on non-interconnected islands (Table 6.1). Most of this growth came from increased capacity of solar PV (+2.5 GW), wind (+2.2 GW) and a new natural gas combined-cycle gas turbine (CCGT) in Megalopolis (+0.81 GW), as well as smaller additions for hydro, biogas and co-generation. Lignite-fired capacity dropped by 1.6 GW with the closure of several older units.

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Table 6.1 Installed capacity in Greece, 2016-2022 and estimated capacity, 2025-2030

Installed capacity (GW)	2016	2017	2018	2019	2020	2021	2022	2025	2030
Natural gas	4.4	4.4	4.9	4.9	5.2	5.2	5.2	6.9	6.9
Lignite	3.9	3.9	3.9	3.9	3.9	2.8	2.3	0.7	0
Wind	2.1	2.3	2.6	3.3	3.8	4.3	4.3	5.2	7
Solar PV*	2.44	2.45	2.49	2.64	3.08	4.0	4.9	5.3	7.7
Large hydro	3	3	3.2	3.2	3.2	3.2	3.2	3.8	3.9
Small hydro	0.22	0.23	0.24	0.24	0.25	0.25	0.26	0.26	0.26
Biogas and biomass	0.06	0.06	0.08	0.09	0.1	0.11	0.1	0.1	0.3
Co-generation	0.1	0.1	0.1	0.11	0.11	0.24	0.12	0.12	0.12
Total	**16.2**	**16.5**	**17.4**	**18.3**	**19.6**	**20.1**	**20.4**	**21.7**	**26.2**

* Including small-scale solar PV in the distribution grid.

The government estimates that installed generation capacity will increase to 26 GW by 2030, mainly because of increasing renewables capacity, primarily solar PV (+2.8 GW), wind (+2.7 GW) and large hydro (+0.7 GW), along with an expected increase of natural gas (+1.7 GW) and smaller additions for biogas, geothermal and solar thermal. As of July 2021, around 4.3 GW of new renewable projects had binding terms for a grid connection, mainly wind (2.4 GW) and solar PV (1.8 GW). The NECP set a target for 19 GW of renewable capacity (excluding large hydro) by 2030 versus around 9.6 GW in 2022.

There are plans to increase fossil fuel generation capacity by around 1.7 GW by 2030. As of June 2022, two fossil fuel plants were under construction, a 0.83 GW CCGT unit in Agios Nikolaos and a long-delayed 0.62 GW lignite unit in Ptolemaida. There are plans to convert this lignite unit to natural gas. The original deadline was 2025, but in 2022, the switch to gas was extended to 2028 to reduce demand for Russian gas following the Russian invasion of Ukraine. Seven other CCGT units (with a total capacity of 5.17 GW) have generation licences and connection offers. However, the government indicates that most probably only two of these units, with a total capacity of 1.72 GW, will be completed by 2030.

Interconnections

Although no new interconnections were deployed since the IEA's last Energy Policy Review in 2017, there was a notable increase in Greece's interconnection capacity, which grew from 1 716 MW (export) and 2 066 MW (import) to 2 468 MW (export) and 2 366 MW (import) in 2022 thanks to higher capacity on the line to North Macedonia, which increased from 350 MW (export) and 450 MW (import) to 1 100 MW (export) and 850 MW (import). In 2022, Greece was interconnected with Albania, Bulgaria, North Macedonia and Türkiye via five 400 kV alternating current (AC) lines (one line to each country); with Albania via one 150 kV AC line; and with Italy via one direct current (DC) undersea cable (Table 6.2).

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Table 6.2 Greece's interconnection capacity, 2022 and growth through 2025

Cross-border interconnection capacity (MW)	2022		2025	
	Export	Import	Export	Import
Albania	250	250	400	400
Bulgaria	400	600	1 400	1 700
Israel	0	0	1 000	1 000
Italy	500	500	500	500
North Macedonia	1 100	850	1 100	850
Türkiye	218	166	660	580
TOTAL	**2 468**	**2 366**	**5 060**	**5 030**

Greece is expanding its interconnection capacity to increase integration with the European electricity market and support its goal of becoming a net electricity exporter. The government has announced that by 2030 it plans to double the capacity of interconnections with Bulgaria, Italy and North Macedonia and triple the capacity of interconnections with Albania (Kokalova, 2022).

There are two ongoing interconnection projects, which should increase total export capacity to 5 060 MW and total import capacity to 5 030 MW by 2025. A new 400 kV AC line with Bulgaria is expected to start operating in 2023. This project has a total cost of EUR 66.3 million and aims to support increased export of renewable generation from Greece and improve electricity trade between the Continental Europe Synchronous Area and Türkiye (via the existing Greece to Türkiye interconnection). In 2021, Greece signed an agreement with other countries in the region to start construction of the EuroAsia Interconnector, a major project to interconnect these countries via two DC subsea cables. The first phase of the project will support 1.0 GW of interconnection capacity with a cost of EUR 2.5 billion. A second phase of the project plans to increase capacity to 2.0 GW.

The TSO's 2021 Ten-year Development Plan calls for investments of EUR 4 billion from 2023 to 2032, with a notable share to boost interconnection capacity. This includes a second DC subsea cable to Italy to raise capacity from 500 MW to 1 000 MW. The TSOs of Greece and North Macedonia are discussing plans to upgrade the existing 400 kV interconnection. The TSOs of Greece and Albania are discussing the possibility of building a new 400 kV interconnection. A working group between Greece, Bulgaria and Türkiye has proposed two projects to boost interconnection capacity: a 400 kV Greece-Türkiye line and a 400 kV Bulgaria-Türkiye line. Greece is also supporting the EuroAfrica interconnector project, which aims to connect Greece and Egypt via a 3.0 GW subsea DC cable, and would serve mainly to export electricity from Egypt (Aposporis, 2022).

Transmission

In 2021, the Greek transmission system was composed of around 12 500 km of AC and DC overhead lines, subsea cables and underground cables, with voltages ranging from 400 kV to 66 kV, and 344 substations, 71 of which are dedicated to connecting renewable generation (Table 6.3). Major developments in the transmission system completed from 2017 to 2021 include interconnecting the mainland transmission system to Crete (Greece's largest and most populous island) and several of the Cycladic islands and upgrading and expanding the network near Megapolis.

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Table 6.3 Greece's electricity transmission system, 2021

Lines and cables in operation (km)	Voltage				Total
	AC 400 kV	DC 400 kV	AC 150 kV	AC 66 kV	
Overhead lines	**2 743**	**107**	**8150**	**39**	**11 039**
Subsea cables	**0**	**0**	**913**	**59**	**972**
Underground cables	**31**	**0**	**381**	**1**	**414**
Total	**2 774**	**107**	**9 444**	**99**	**12 425**

By 2030, the TSO plans to add at least 4 000 km of new transmission lines and at least 22 new substations (excluding those needed to support new renewable generation). The 2021 Ten-year Transmission Development Plan places a strong focus on continuing the interconnections of isolated islands to reduce their reliance on oil-fired generation and allow the export of renewable generation from the islands to the mainland. Projects under construction include a second interconnection to Crete (EUR 1.04 billion, completion 2024), and interconnection to the south and west Cycladic islands (EUR 0.41 billion, completion 2024) and to Skiathos island (estimated EUR 60 million). Planned projects include the interconnection of Dodecanese (EUR 1.5 billion, completion 2028) and the Northeast Aegean islands (EUR 0.89 billion, completion 2029) to the mainland power system. Completion of these projects would link most of the islands to the mainland.

The TSO also plans to increase the capacity and reliability of the mainland grid, aiming in particular to support exports of renewable electricity generation. Key projects include the expansion of the 400 kV grid towards Peloponnese (EUR 98 million, completion in 2024), new 400 kV lines between Nea Santa and Filippi (EUR 49 million, completion in 2027) and new extreme high-voltage substations in Attica.

Distribution

In 2020, the Greek electricity distribution system was composed of around 7.6 million metered connections, around 242 000 km of lines and around 165 000 substations (Table 6.4). There is only one DSO (HEDNO), but it has five regional departments that are responsible for network operation and maintenance in their service area (Figure 6.5). The DSO is planning major projects to expand and upgrade the distribution system. In June 2021, it signed an agreement with the European Investment Bank for a EUR 330 million loan to support the construction of 6 600 km of new power lines, upgrading of 7 600 km of existing lines and the deployment of smart meters. The DSO is also investing in deploying digital smart meters to all consumers by 2030. These investments are intended to improve system performance and increase the integration of renewable generation (EIB, 2021).

Table 6.4 Greece's electricity distribution system, 2020

Voltage	Lines (km)	Connected consumers	Substations (number, voltage)
Low	128 211	7 580 744	165 290, low to medium
Medium	113 358	12 668	241, medium to high
High	**993**	**No data**	
Total	**242 562**	**7 593 412**	**165 531**

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Figure 6.5 Regional departments of the Greek electricity distribution system operator

Non-interconnected islands

Greece has made significant progress in interconnecting its islands to the mainland grid. However, in 2020, 47 populated islands were still not interconnected, some of which are linked to each other to form a total of 29 autonomous systems. Together these systems had a total of around 780 000 metered connection points and a total electricity demand of around 4.4 TWh (compared to 7.6 million connections and 48.8 TWh of demand in the interconnected system). Almost all generation on non-interconnected islands is based on diesel.

The DSO is responsible for managing the electricity systems and markets on each of the non-interconnected islands. PPC is the main electricity supplier on non-interconnected islands, accounting for 82.6% of total consumers and 73.9% of total demand in 2020. PPC's shares of consumers and demand both declined by around 5% compared to 2019. Retail prices on non-interconnected islands do not reflect generation costs but are set by the DSO based on average retail prices in the interconnected system. The difference

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between the retail price and the actual cost of electricity is covered by a public service obligation fee charged to all consumers in the interconnected system. In 2020, fees to cover the higher costs of diesel generation on non-interconnected islands totalled EUR 400 million.

The government has a goal to interconnect all populated islands to the mainland grid by 2030. Significant investments are committed to the interconnection of islands in the 2021 TSO Ten-year Development Plan (EUR 3 billion) and in Greece's recovery and resilience plan (EUR 200 million). The government is also supporting the deployment of renewable generation on the islands.

Market structure

Greece is undertaking notable changes to its wholesale electricity market mechanisms to support full integration into the European common wholesale electricity market. In addition, under the terms of the bailouts received from 2010 to 2019, Greece is required to privatise a wide range of state-controlled companies and assets as part of a wider effort to increase market competition. This included the privatisation of PPC (the incumbent electricity utility) in November 2021. PPC still plays a dominant role in Greece's electricity market. It owns the largest share of installed generation capacity (46% in 2020 and 40% in 2021, including most lignite-fired generation and associated mines, and all large-scale hydro generation). It is also the largest electricity supplier at the wholesale level (46% market share in 2020 and 42% in 2021) and retail level (63% market share in 2020). Legislation sets a target to reduce PPC's share of the retail market to 50% or less.

Capacity market

Greece's electricity market functions mainly as an energy-only market where suppliers are paid for electricity (MWh) delivered to consumers. From 2016 to 2020, a capacity market mechanism aimed to address resource adequacy concerns by providing payments based on guaranteed availability of capacity (MW). Legislation passed in 2019 calls for the creation of a new capacity remuneration mechanism that will award capacity payments through competitive auctions run by the TSO. The government is developing the rules for the capacity remuneration mechanism, which is expected to start operating in 2023.

Wholesale market

To support better integration with the European common wholesale electricity market and ensure more competitive and efficient wholesale electricity trading, Greece is implementing structural changes to its wholesale electricity market (Figure 6.6). A day-ahead mandatory pool system, in operation since 2005, was replaced in 2020 with three wholesale spot markets (day-ahead, intraday and balancing) and a derivatives market. The day-ahead, intraday and derivatives markets are operated by Hellenic Energy Exchange (HEnEX), while transaction clearing is performed by the Athens Exchange Clearing House (ATHEXClear) for the derivatives market and the Hellenic Energy Exchange Clearing House (EnExClear) for the spot markets. The balancing market is operated by the TSO.

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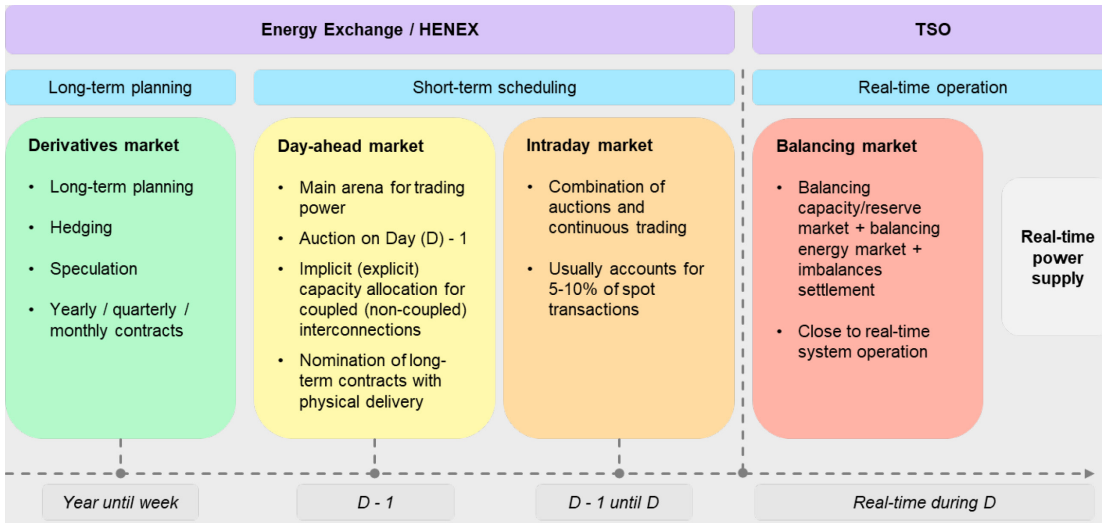
Figure 6.6 Operation of the Greek wholesale electricity market



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The derivatives market offers future contracts for both base load and peak load profiles, covering monthly, quarterly and yearly periods. Participants in the derivatives market can be generators, suppliers, traders, aggregators and consumers. To date, this market has no liquidity, with no significant contracts concluded. Aiming to address the issue of limited liquidity in the bilateral and forward products and to enhance competition in the derivatives market, the RAE issued Decision 928/2022 to increase the cap on quantities of forward exchanged and bilateral contracts of vertically integrated suppliers from 20% to 30%, for suppliers with a market share higher than 40% in supply (thus, applying to PPC only).

The day-ahead market is the main spot market for trading electricity. It is an auction market run at noon on the day preceding the delivery day and covers the entire delivery day in 24-hour units. The market participants are generators, consumers, suppliers, traders and aggregators. Participation in the day-ahead market is mandatory for thermal generators. Participants are allowed to submit orders between -500 EUR/MWh and 3 000 EUR/MWh. The day-ahead market is coupled to other European day-ahead markets through the Single Day-Ahead Coupling project via the Greece-Bulgaria and Greece-Italy interconnections.

The intraday market consists of an auction mechanism, with a continuous trading mechanism entering operation in November 2022. Participation in the intraday market is not mandatory. The intraday market aims to reduce exposure to imbalance costs by allowing participants to modify existing positions (e.g. generation schedule, load declarations, etc.) close to the time of the physical delivery, considering deviations of the day-ahead market schedule and limitations on the balancing market. The auction trading mechanism consists of three auctions per delivery day. Since November 2022, Greece has been participating in the European Intraday Continuous Market; participation the Pan-European intraday auctions will start in 2024. Market participants are allowed to submit orders to the regional intraday auctions between -9 999 EUR/MWh and 9 999 EUR/MWh. In September 2021, the intraday market started supporting complementary regional intraday auctions covering the electricity markets of Greece, Italy and Slovenia; the remaining capacity of the Greece-Italy interconnector has been implicitly allocated via the three available intraday auctions ever since.

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Following approval from the European Commission in July 2022, a new temporary mechanism is applied in the Greek wholesale market (day-ahead and intraday – including auctions and continuous trading), intending to decouple the electricity generation exchange price from the gas price and mitigate the economic impact on consumers. The mechanism, which is valid until 1 June 2023, introduces a revenue cap on producers' income through the enforcement of price caps on each power generation source (natural gas, lignite and renewables) and is activated at the markets' settlement procedure (as an *ex post* scheme – aiming to minimise the impact on the spot price formation) to automatically return the excess market value generated from high wholesale prices to the national Energy Transition Fund, which subsidises the final consumers.

The balancing market includes a balancing capacity market (to ensure that sufficient reserves are available) and a balancing energy market (to activate energy in real time to ensure that the system is in balance while meeting the demand for energy and reserves and respects all technical plant operation constraints) and the integrated settlement process (to allocate revenues and costs of the balancing market to market participants).

A notable share of Greece's wholesale electricity supply is delivered via cross-border interconnections. Electricity traders purchase long-term physical transmission rights to use the cross-border interconnections via auctions run by the TSO. Some capacity is reserved for the day-ahead market, where transmission capacity is allocated together with electricity imports. In November 2022, continuous intraday trading on Greek-Italian and Greek-Bulgarian borders went live through the European XBID project. Within this framework, market participants can trade across borders continuously and closer to the delivery time to improve market schedules and lower imbalance costs.

Market competition

A 2020 report from Eureletric (the association of European utilities) notes that Greece had one of the most highly concentrated electricity markets in Europe, along with, for instance, Croatia, Ireland and Slovenia (Eurelectric, 2020). The European Union Agency for the Cooperation of Energy Regulators' 2020 market monitoring report noted that Greece faces significant obstacles that prevent the efficient formation of wholesale electricity prices and limit access for new and small market participants (ACER and CEER, 2021).

The Herfindahl-Hirschman Index (HHI) for Greece's wholesale market has significantly improved. The HHI for wholesale generation fell from 7 820 in 2015 to 4 434 in 2020 and 4 888 in 2021. For generation capacity, it dropped from 6 804 in 2015 to 6 350 in 2020 and 6 054 in 2021. However, both these values indicate that Greece's wholesale market remains extremely concentrated and lacks competition.[4] In 2020, PPC was the dominant wholesale electricity supplier, accounting for 46.4% of total electricity generation and 45.9% of installed capacity. The next largest share of wholesale supply (32.7%) came from renewable aggregators.

Upcoming market developments

Pan-European intraday auctions are planned to go live in 2024. For the Greek wholesale market, the intraday auctions will be an evolution from regional to European-level auctions.

[4] The HHI is an indicator for market competition. It ranges between 0 for an infinite number of small firms (maximum competition) and 10 000 for one firm with a 100% market share (no competition). An HHI above 2 000 signifies a highly concentrated market with a small number of firms.

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The introduction of the intraday auctions should further boost liquidity in the intraday auctions, optimise the allocation of the interconnector capacity, provide intraday-level congestion pricing signals, and further increase the European social welfare.

By 2025, it is planned for the Greek day-ahead market to offer 15- and 30-minute orders in addition to the existing 60-minute orders. This should improve market participants' trading options and market schedules. It should also allow renewable aggregators to fine-tune market schedules and reduce imbalances within the balancing market, which is already using a 15-minute resolution.

Retail market

Greece does not regulate electricity prices, which are set by market forces for most consumers. Consumers are free to choose their supplier, and any company may enter the market as a supplier. All suppliers must publish tariff conditions. The RAE operates a tariff monitoring and supervision system for consumer protection.

In 2020, 26 suppliers were active in the retail electricity market of the interconnected electricity system. However, the retail market is still dominated by PPC, which in 2020 accounted for 77.8% of connections and 63.2% of demand at low and medium voltage and 96% of demand at high voltage. However, PPC's market share has fallen notably, from 96.3% of demand in 2015.

In 2020, 7.8% of retail electricity consumers (accounting for 8.1% of demand) in the interconnected system at low and medium voltage switched suppliers (Table 6.5). This switching rate was above average for liberalised retail electricity markets in Europe. The Greek supply code allows retail suppliers to unilaterally switch consumers from a fixed-rate contract to a variable rate contract six months after sending a notification. This has become common practice, resulting in a strong increase in retail prices as suppliers pass high wholesale costs directly on to consumers. The Greek supply code also allows consumers to switch to a new supplier without having to pay the debts with their current supplier.

Table 6.5 Switching rate in the interconnected system in Greece, 2020

Consumer category	Total customers	Switching rate (number)	Total demand (MWh)	Switching rate (volume)
Household (excluding social tariff)	4 871 122	8.69%	13 857 593	3.58%
Household under social tariff	437 137	0.01%	1 866 835	1.48%
Small industry and commercial	1 170 250	8.83%	8 806 167	10.51%
Other low voltage	306 055	0.87%	3 032 509	0.78%
Total low voltage	6 784 564	7.80%	27 563 105	5.34%
Large industry and commercial	9 757	8.40%	8 565 062	17.75%
Other medium voltage	1 713	1.46%	1 487 193	4.23%
Total medium voltage	11 470	7.37%	10 052 255	15.75%
Total	**6 796 034**	**7.80%**	**37 615 360**	**8.12%**

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Greece took important steps to increase transparency in the retail market after the last IEA Energy Policy Review in 2017. The RAE issued a decision requiring increased transparency on variable pricing and a decision prescribing templates for pre-contractual information and for the electricity bill. The RAE improved its price comparison tool and developed a retail monitoring tool and a pricing database. The RAE established a sanctioning process and positive reporting of suppliers, which according to the RAE, has proved to be more effective than sanctions for overdue payments to network operators.

The social tariff (established in 2010) provides discounted electricity rates for several categories of economically or socially vulnerable residential consumers. The discounted rates are set by the government and vary depending on the category of consumer and their level of electricity demand. In 2022, the rates were 0-70 EUR/MWh for four months of demand up to 800 kWh, 40-80 EUR/MWh for four months of demand from 0.8 MWh to 1.5-1.7 MWh, and 95 EUR/MWh for four months demand over 1.5-2 MWh (with the upper limits depending on the type of consumer). These are notable reductions compared to the average retail price of approximately 240 EUR/MWh in 2021.

The social tariff is financed mainly through a public service obligation fee charged to all electricity consumers that do not qualify for the social tariff. All electricity suppliers are obliged to offer the social tariff to qualifying consumers. The government estimates that in 2019, 500 000-550 000 households benefited from the social tariff. Households and small commercial consumers that are unable to find a supplier on the retail market are served by a supplier of last resort (the largest supplier in a DSO area).

Retail prices and taxes

In 2Q 2022, Greece's household prices were the tenth-highest in the IEA at 272 USD/MWh, with a tax rate of -20%, compared to an IEA average price of 255 USD/MWh and an average tax rate of 16%. Industry prices were the second-highest in the IEA at 243 USD/MWh, with a tax rate of -16%, compared to an IEA average price of 174 USD/MWh and an average tax rate of 5.2% (Figure 6.7).

Retail electricity sales are subject to a reduced VAT (6% instead of 24%) and an excise duty of 2.2 EUR/MWh for households, 5.0 EUR/MWh for small industry (demand less than 10 GWh per year) and 2.0 EUR/MWh for large industry (demand greater than 10 GWh per year). Large electricity plants are required to purchase ETS allowances based on their GHG emissions, with these costs passed on to final consumers. Electricity consumers are also subject to a fee that finances the public service obligations, including the social tariff, supplying non-interconnected islands at the same prices as the mainland and discounted electricity to entities that provide social welfare.

Electricity consumers also pay a Special Duty of Greenhouse Gas Emissions Reduction (ETMEAR) to fund the Special Account for Renewable Energy Sources, which finances subsidies for renewable electricity and high-efficiency co-generation projects. In 2019, the ETMEAR was reduced from 23 EUR/MWh and set at 17 EUR/MWh through 2028. Also in 2019, the ETMEAR rate was reduced for agriculture, lignite mines, railroads, businesses and energy-intensive industry, with the lowest rate (energy-intensive industry) set at 2.55 EUR/MWh. Electricity bills are also used to collect a national radio and television fee (3.00 EUR/month) and municipal and real estate taxes. The numerous fees and charges applied to electricity bills create a complex bill that makes it difficult to determine how

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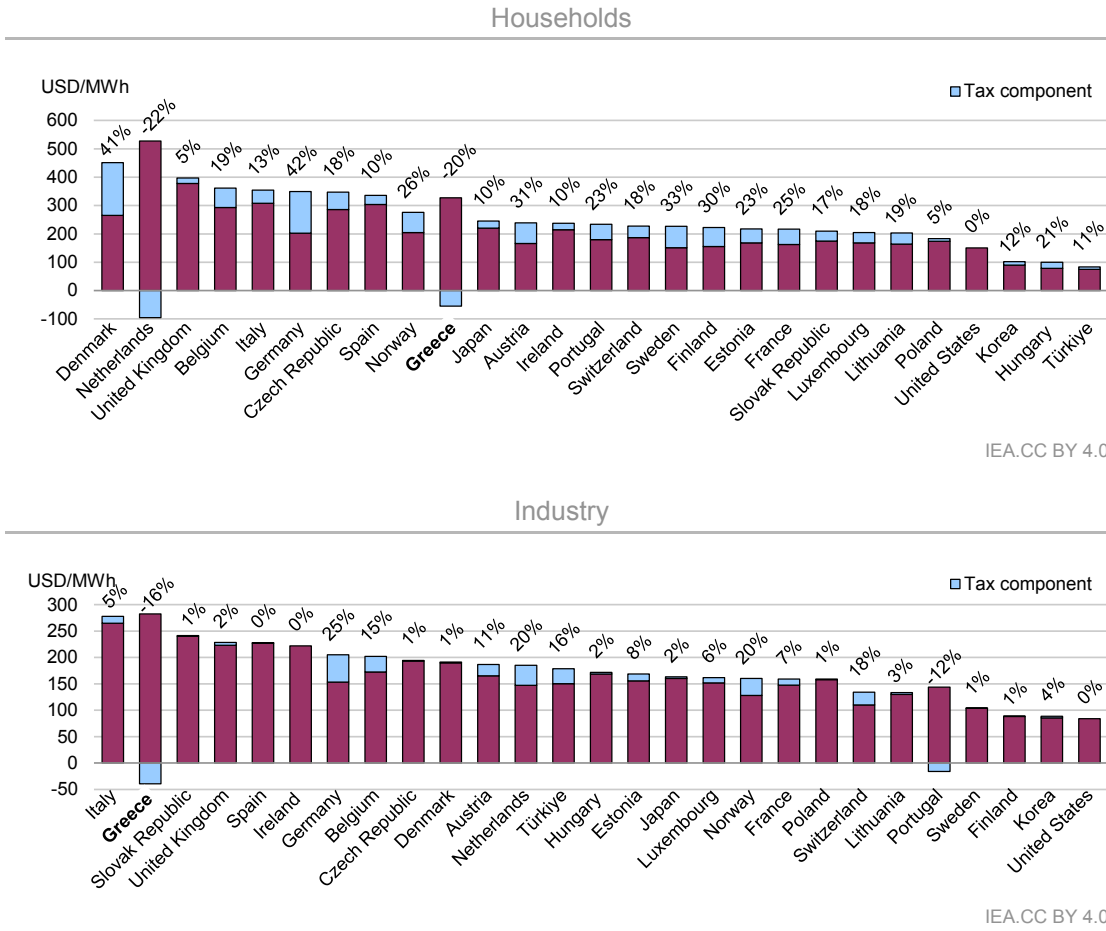
electricity consumption affects the total amount charged, reducing the incentive to save energy when electricity prices increase.

Lignite-fired generation owned by PPC is subject to a special lignite fee of 2 EUR/MWh based on net electricity generation. PPC is also charged a special tax equal to 0.5% of its annual turnover. Revenue from these taxes is used to support the communities impacted by the phase-out of lignite-fired generation and associated mining.

Figure 6.7 Annual average household and industry electricity prices in Greece, 2Q 2022



Notes: Industry and household prices are unavailable for Australia, Canada, Mexico and New Zealand. Tax information is not available for Ireland or the United States.

Source: IEA (2022c).

In September 2022, the government introduced a 10 EUR/MWh tax for gas used in gas-fired electricity generation. Revenue from the tax will go to the Energy Transition Fund to reduce consumer energy bills and will also support investments in biomethane and low-carbon hydrogen production projects and the expansion of natural gas infrastructure that helps end dependence on Russian gas. However, this tax will increase generation, likely resulting in higher consumer bills.

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Electricity policy

Greece's energy policy aims to substantially reduce GHG emissions from the electricity sector to support the achievement of climate targets while maintaining security of electricity supply and ensuring affordable electricity prices. Key policies include a legal requirement to phase out lignite-fired generation by 2028, a target to increase the share of renewable electricity generation to 61% by 2030, and goals to boost the share of renewables in transport and buildings through increased electrification. Greece also aims to decarbonise electricity supply and increase grid flexibility through the deployment of electricity storage and DSR measures. The government has a goal to interconnect all populated islands to the mainland grid by 2030.

The government sees gas-fired generation as a key technology to support the reduction of lignite-fired generation while maintaining dispatchable generation for system balancing. However, the role of gas is being re-evaluated following the Russian invasion of Ukraine and continued gas price volatility.

Greece is also reducing notable barriers to licensing and grid connections for renewable energy projects (see Chapter 4). There have been two major updates to legislation (May 2020 and July 2022) that aim to reduce the duration of the licensing process from an average of 5 years (with some projects taking much longer) to 24 months, to facilitate the granting of licences to 12 GW of renewable energy projects by 2030. The July 2022 law also intends to decrease grid congestion, and the TSO and DSO are making significant investments to expand grid infrastructure and reduce the waiting time to connect renewables generation.

Measures to address high electricity prices

Starting in the third quarter of 2021, global energy prices began to increase rapidly, especially in Europe. Price spikes and high volatility persisted into 2022, driven mainly by the impacts of the Russian invasion of Ukraine. In December 2021, the average day-ahead spot market price in Greece reached 235 EUR/MWh, compared to just 52 EUR/MWh in January 2021. Average day-ahead market prices remained above 210 EUR/MWh for all of 2022 and peaked at 436 EUR/MWh in August 2022 (Argus Media, 2022). Greece is taking numerous measures to limit the impact of high energy prices, especially for vulnerable consumers. These include expanding existing measures targeting energy poverty and introducing other measures to reduce energy prices for most consumers. Greece's Energy Transition Fund (established in 2021) supports a variety of subsidies for electricity, natural gas, heating oil and road transportation fuels to combat energy poverty and reduce the impact of high energy prices. The fund is financed via several sources, including a share of ETS allowances and surplus revenues from fees relating to public service obligations and renewable support measures. From September 2021 to November 2022, Greece dedicated EUR 9 billion to energy subsidies and other measures to help consumers pay their utility bills (Reuters, 2022).

In September 2021, the government established a one-time fee on profits earned by generators in Greece's wholesale electricity market between 1 October 2021 and 30 June 2022. The revenues collected via the fee were directed to the Energy Transition Fund. The fee mainly affected generation from lignite, natural gas and large hydro, as it did not apply to renewable energy or co-generation assets that receive subsidies or earn their revenue

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outside the wholesale market (Tax Heaven, 2022). The total revenue from the one-time windfall profit fee is around EUR 500 million.

In July 2022, the government introduced wholesale electricity market price caps to insulate consumers from continued high prices. The caps for generation from natural gas and lignite are based on fuel costs and ETS allowance prices and are adjusted on a monthly basis. In December 2022, the price cap was 240 EUR/MWh for gas-fired generation and 200 EUR/MWh for lignite-fired generation. The price caps for large hydropower (112 EUR/MWh) and other renewables (85 EUR/MWh) are fixed. Revenue that electricity producers receive from prices above these caps is directed to the manager of the Energy Transition Fund to be distributed to consumers (Fintikakis, 2022).

In October 2022, the government updated the subsidy for electricity bills paid to all consumers to a three-bracket system, with higher subsidies for lower consumption levels and additional discounts to reward energy savings. For consumers with demand from 0 kWh/month to 500 kWh/month, the subsidy is 436 EUR/MWh. For consumers with a demand of 501-1 000kWh/month, the subsidy is 386 EUR/MWh but can be increased to 436 EUR/MWh if demand is reduced by at least 15% compared to the previous year. For consumers with demand above 1 001 kWh/month (less than 2% of households), the subsidy is 336 EUR/MWh but can be increased to 386 EUR/MWh if demand is reduced by at least 15% compared to the previous year. For businesses with a demand of more than 2 000 kWh, the subsidy is 398 EUR/MWh. For consumers receiving the social tariff, the subsidy is 485 EUR/MWh regardless of the level of demand. Farmers will receive a subsidy of 436 EUR/MWh. The government estimates these subsidies will cost around EUR 1.1 billion.

Lignite phase-out

Under the 2022 Climate Law, lignite-fired generation must be phased out by 2028. Greece has already made notable progress on this goal. From 2010 to 2020, the share of lignite-fired generation in total electricity generation fell from 54% to 14%. The plan to phase out lignite-fired generation aims for increased gas-fired generation capacity to take on the role of balancing electricity supply and demand (see Chapter 7) while also strongly expanding generation from renewables (see Chapter 4).

Prior to the Russian invasion of Ukraine, PPC was planning to close most lignite-fired generation by 2023 and to convert the newest lignite-fired plant (still under construction) to natural gas by 2025. In June 2022, the government and PPC announced that the phase-out of lignite-fired generation was being extended to 2028. At the same time, PPC noted it would increase lignite extraction in 2022 from 10 Mt to 15 Mt, with the additional coal to serve as a security reserve in case of disruptions in Russian gas imports.

The National Fair Transition Fund (established in 2018 and financed by a small share of ETS allowance revenues) supports economic transition in the regions of Greece where lignite mining and power generation are a key part of the economy (the Florina and Kozani regions and the Megalopolis municipality). In 2021, Greece was allocated EUR 755 million from the EU Just Transition Fund to support regions affected by the lignite phase-out.

Several of the regions impacted by the lignite phase-out are seeing increasing investment in renewable generation. In April 2022, the 204 MW Kozani solar PV project started operating. It is sited next to several lignite mines, is the largest utility-scale solar farm in south-eastern Europe and is the first phase of 3 GW of solar PV planned to be built in Greece's lignite regions (Beyond Coal, 2022).

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Renewable generation and electrification of energy demand

Greece's energy policy aims to rapidly accelerate the use of renewable energy and sees this as essential to achieving its 2030 climate targets and long-term goals for net zero emissions (see Chapter 4). The government aims to boost the use of renewables across the economy, mainly through a strong increase in renewables electricity generation (mostly wind and solar PV), linked to the widespread electrification of energy demand, especially for building heating and cooling and road transport. The NECP has a target for 19 GW of renewable capacity (excluding large hydro) by 2030 versus around 9.6 GW in 2022.

Greece has recently made several significant changes to its support scheme for renewable electricity generation that aim to increase the rate of deployment and ensure low electricity prices. An updated auction system provides subsidies for renewable generation that are awarded through competitive auctions and reflect market prices. Planned auctions aim to support the deployment of 4.2 GW of solar PV and wind from 2022 to 2025, with a budget of EUR 2.27 billion. Greece is also seeing a notable increase in renewable energy projects being developed with no subsidies through power purchase agreements and other long-term contracts. In August 2022, the Greek parliament approved the country's first Offshore Wind Law, which aims for 2 GW of offshore wind capacity by 2030. The government is still in the process of developing the regulatory framework for offshore wind and setting up an auction system that will award support for offshore wind.

Greece provides financial support for the electrification of energy demand (see Chapter 3). This includes direct subsidies and tax breaks to encourage the adoption of EVs and the deployment of EV charging infrastructure. There are plans to electrify the whole rail network and connect big ports to railway. Some of Greece's support measures for building renovations include the support (subsidies, loans, tax breaks, etc.) for the electrification of heating and cooling demand (including with heat pumps) and the deployment of renewable electricity generation on buildings.

System flexibility

Greece is improving grid flexibility to support the integration of renewable generation, alleviate network congestion, increase system flexibility, and promote balancing market liquidity and transparent electricity price formation. Key measures include progressively deploying smart meters to most consumers by 2030, increasing support for energy storage and including DSR in the balancing market. Greece is also aiming to increase system flexibility through participation in the common European platforms for the exchange of balancing energy, such as MARI (Manually Activated Reserves Initiative), PICASSO (the Platform for the International Coordination of Automated Frequency Restoration and Stable System Operation) for the exchange of balancing energy by manual and automatic frequency restoration reserves, respectively, and the IGCC (for the process of clearing imbalances).

Smart meters

Greece has a limited deployment of smart meters. However, the electricity DSO plans for all consumers to have a smart meter by 2030. As of 2021, 13 000 smart meters had been deployed at the medium-voltage level and 70 000 at the low-voltage level, mainly for consumers with high electricity demand. In July 2022, the DSO announced it was working to finalise a tender process to select companies to deploy up to 7.7 million smart meters, with additional tenders as needed to complete the smart meter roll-out. The tenders cover

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three products: 1) field equipment (metering units and point-to-point communication equipment); 2) advanced metering infrastructure systems (software); and 3) meter data management systems. In 2022, 100 000 smart meters were installed; the DSO estimates that this will increase to 500 000 in 2023 and between 800 000 and 1 million each year from 2024 to 2030. The full smart meter roll-out is expected cost around EUR 1 billion. The RAE has approved the recovery of the costs through DSO tariffs (Mononews, 2022).

The DSO will collect and manage all smart meter data and establish rules for market actors to access it. Customers will access their own data through a portal.

Demand side response

Historically, DSR has played a limited role in Greece's electricity system. From 2016 to 2022, the TSO ran auctions for an interruptible load service, under which large consumers (at least 3 MW of demand) connected to the high- and medium-voltage transmission system could receive fixed payments to reduce demand in situations when the market did not support system balancing. Greece aims for DSR to play a much larger role in supporting efficient grid operations and integrating wind and solar PV generation. In October 2022, Greece launched a new platform supporting DSR participation in the electricity balancing market (which replaced the interruptible load service system). The platform allows consumer participation of all demand levels, with distributed DSR possible through the aggregation of at least 1 MW of DSR capacity (see Chapter 4).

The platform is already encouraging increased DSR participation. As of January 2023, the RAE-approved licences allowed the provision of a total of 2 950 MW of DSR in the balancing market, with the largest licences going to PPC (1 000 MW), Elpedison (500 MW), Sympower (500 MW), MYTILINEOS (500 MW), Optimus (350 MW) and NRG (100 MW). Licences have been issued to several large industry consumers along with several companies that aggregate DSR from numerous smaller consumers.

There is an ongoing process to update regulations to support DSR participation in all areas of the wholesale electricity market (as required under EU regulations). HEnEX is preparing an amendment to the Day-Ahead and IntraDay Market Regulation to allow DSR participation in these markets. The RAE will review the amendment, and the government has indicated that an updated regulation allowing DSR participation in the day-ahead and intraday markets will be issued in 2023.

Energy storage

Pumped hydro storage plays a notable role in Greece's electricity system and markets, and there are plans to increase electricity storge capacity. As of June 2022, Greece had two large-scale pumped hydro storage facilities in operation: Thissavros (0.38 GW) and Sfikia (0.33 GW). There is currently very little battery energy storage in Greece. At the end of 2021, the RAE had issued a total of 181 licences for electricity storage projects with a total capacity of 14.3 GW, including 14 pumped storage projects with a total capacity of 3 GW. A law passed in July 2022 sets a goal for the deployment of 3.5 GW of energy storage (excluding large hydro) by 2030, a notable increase from the NECP target of 1.4 GW of storage by 2030.

Greece has created a dedicated aid scheme for energy storage projects, which the European Commission approved in September 2022. It has a budget of EUR 341 million (partly funded by the EU Recovery and Resilience Facility) to support the construction and operation of around 0.9 GW of electricity storage connected to the high-voltage grid. The

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support will be awarded through a competitive auction which will take place before the end of 2023. Selected projects should be completed by the end of 2025. The aid will be granted as an investment grant paid during the construction phase and ten years of annual support paid during project operations. The annual support will be based on submitted bids but can be reduced if the project has excess market revenues (EC, 2022).

The July 2022 law also made changes to clarify and accelerate the licensing process for energy storage projects. It creates clear legal and regulatory definitions for energy storage, including options for stand-alone storage and storage incorporated with renewable generation. The law expands the potential revenue streams for storage projects by giving them the right to participate in the intraday and balancing markets (previously storage was only allowed to participate in the day-ahead market). The law allows the TSO to deploy and operate energy storage with the approval of the MoEE (in which case the storage assets cannot participate in the market but only support grid operations) or if the RAE determines that there is a relevant need that cannot be met by third parties.

The largest ongoing energy storage project in Greece is the pumped storage hydro facility at Amfilochia, with a capacity of 0.68 GW for generation and 0.73 GW for pumping. The project cost is estimated at EUR 550 million, with EUR 250 million coming from the EU Recovery and Resilience Facility. Construction began in November 2022 and it is expected to start operations by 2025. Greece is also starting to deploy large-scale battery storage.

Electricity security

The RAE is responsible for electricity emergency policy, including monitoring the security of electricity supply. The RAE has been appointed as the Competent Authority for the implementation of EU Regulation 2019/941, which sets requirements for all EU member states in relation to risk preparedness in the electricity sector. The RAE is responsible for developing national crisis scenarios and drafting a risk preparedness plan, which was supposed to be published by 5 January 2022; according to the government, the risk preparedness plan is still under development.

The government is preparing an emergency plan to save energy in the event of a prolonged interruption of Russian gas supplies (Todorović, 2022). This plan involves measures to cut electricity consumption in public buildings, with limits on the use of air conditioners, lights and electrical appliances, and setting the temperature at 26-27°C in the summer and 19-20°C in the winter. For extreme limitations in gas supply, rolling power outages are envisaged on workdays and limits to electricity supply for energy-intensive industries and companies in the medium-voltage network that are not in the supply chain for basic necessities.

Greece has numerous measures in place to ensure the availability of generation in an emergency. The TSO control centre has a defence plan that provides guidelines and operation principles for emergencies. In an emergency, the TSO increases operating reserve capacity through measures such as procurement of balancing capacity. Automated load-shedding strategies can be activated in co-operation with the DSO whenever the system operator deems it appropriate.

There is a strong focus on maintaining a secure supply of natural gas, as gas-fired power plants provide the largest share of generation (41% in 2021) and play a key role in

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electricity system balancing. One of the key goals of Greece's gas emergency response policy is maintaining supply for electricity generation (see Chapter 7). Gas-fired electricity plants are required to submit an annual report each October to the RAE detailing how they have secured adequate gas supplies, especially during the winter period (from December to February). If the RAE has concerns, it can ask the plant owner to take additional steps to ensure adequate gas supplies.

Greece does not have large-scale gas storage; however, a small share of storage capacity at the LNG terminal is reserved for electricity generation in emergency situations. The amount of LNG security reserves is calculated for each obligated holder of an electricity generation licence and must cover 16 hours per day for 5 days for each power plant. For the winter of 2021/22, the LNG security reserve totalled 67.2 m^3 of LNG (around 0.04 million cubic metres [mcm] of natural gas). To ensure secure 24-hour operations, the LNG terminal has an onsite co-generation unit and, as a backup, can be supplied through two independent 20 kV distribution lines, each of which is able to fully meet the electricity demand of the terminal.

Following the Russian invasion of Ukraine, Greece is taking steps to ensure gas supply in case Russian imports are no longer available. In September 2022, DEPA Commercial reached an agreement with TotalEnergies of France that allows for deliveries of two LNG cargoes each month through March 2023. The government estimates this could substitute almost 100% of Greece's gas imports from Russia (Ekathimerini, 2022). In response to Russia's invasion of Ukraine and new EU requirements on gas storage, Greece has agreed with Italy to store 100 mcm of gas in a storage facility in Italy. This volume is equal to 1.6% of Greece's annual demand. Greece and Italy are linked by the Trans-Adriatic Pipeline (TAP) gas pipeline and in an emergency situation, the TAP can support reserve flows (virtual or real) to Greece.

In case of a gas supply crisis, the security of electricity supply is supported by five gas-fired power plants that can switch from natural gas to diesel. These plants are obligated to ensure uninterruptible operation using diesel for at least five days under partial load and must keep the needed level of diesel stored onsite. These plants have a total generation capacity of 2.0 GW when fuelled with gas and 1.8 GW when fuelled with diesel (compared to a peak demand of Greece of 8.6 GW in 2020). Greece has also taken steps to allow lignite-fired generation to replace gas during a supply emergency. Following the Russian invasion of Ukraine, PPC delayed the phase-out of lignite-fired generation and increased the stockpiling of lignite.

Greece is also taking steps to ensure the cybersecurity of the electricity system. In 2020, the government adopted a cybersecurity strategy for the period 2020-2025, which details measures to protect network and information systems for all critical infrastructure, including the energy sector. The National Cybersecurity Authority at the Ministry of Digital Policy is the competent authority for the implementation of the national cybersecurity strategy. For cybersecurity issues related to the energy sector, the National Cybersecurity Authority consults with the MoEE, the RAE, the Hellenic Centre for Security Studies and the Hellenic National Defence General Staff. The electricity TSO has taken various measures to strengthen cybersecurity.

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System performance

From 2016 to 2020, the System Average Interruption Frequency Index (SAIFI) [5], System Average Interruption Duration Index (SAIDI)[6] and losses for Greece's electricity distribution system fluctuated with no clear trend of improving or declining performance (Table 6.6). SAIFI improved for the electricity transmission network, while SAIDI worsened (Table 6.7). These are among the lower values in Europe, indicating notable room to improve system performance (Eurelectic, 2019).

Table 6.6 Distribution network interruption statistics in Greece, 2016-2020

	2016	2017	2018	2019	2020
Not including exceptional events					
SAIFI	1.47	1.51	1.62	2.06	1.6
SAIDI	96	97	119	140	111
Including exceptional events					
SAIFI	2.03	1.95	2.03	2.57	1.99
SAIDI	132	131	173	190	146
Losses (% of annual energy injection)					
Losses	9.7%	9.3%	9.7%	9.9%	9.8%

Table 6.7 Transmission network interruption statistics in Greece, 2017-2020

Metric	2017	2018	2019	2020
SAIFI	0.310	0.90	0.220	0.190
SAIDI	18.41	25.22	24.12	22.03

Assessment

Greece aims to reduce greenhouse gas emissions from the electricity sector. Greece maintains an ambitious lignite decommissioning plan, despite the short-term decision to increase lignite extraction and generation for security of supply reasons. The role of natural gas in the electricity sector is being re-evaluated following the Russian invasion of Ukraine and the sharp and sustained increase in gas prices.

Next to decarbonising electricity supply, Greece also aims to increase system flexibility and grow exports of renewable electricity through major grid investments (including for cross-border interconnections), reforms to reduce delays in licensing of renewable projects, changes in market rules to allow full participation of renewables and the

[5] SAIFI is a system index of average frequency of interruptions in power supply, measured as a total number of interruptions divided by the number of all customers.

[6] SAIDI is a system index of average duration of interruption in the power supply indicated in minutes per customer per year. It is measured by multiplying the average duration of customer interruptions by their total number then dividing by the total number of customers in the system.

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deployment of energy storage, and demand side response. Extending the grid to non-interconnected islands is a major priority to reduce the use of oil-fired generation.

Wholesale electricity markets

Greece is making major changes to its wholesale electricity market regulation to align it with the European common wholesale electricity market and ensure more competitive and efficient wholesale electricity trading. While the HHI for Greece's wholesale market has improved, it still indicates high concentration and low competition.

Greece has successfully completed a number of reforms in the wholesale electricity market in the last five years (electricity market design, unbundling of electricity and gas TSOs). Greece has also started to successfully implement its recovery and resilience plan with significant reforms and investment in the electricity market. In 2022, several reforms were completed, like demand side response participation in the market and simplification of renewables permitting. More reforms and investments are needed for Greece to achieve its ambitious plans regarding the green transition while addressing the significant geopolitical challenges and increased energy prices. Ensuring security of supply while increasing competition in the markets and ensuring affordable prices for vulnerable consumers in the short, mid and long term are essential.

Greece plans to complete the wholesale electricity market design reforms. The day-ahead market is the main market segment with sufficient liquidity because of the mandatory participation of electricity producers (apart from renewables). Reforms are still pending in the intraday and balancing segments. In the short term, reforms in the intraday market are a high priority to further enhance competition through the integration of renewables and DSR (including via aggregators) and the full participation of electricity traders.

Greece was integrated into the Pan-European intraday coupling (XBID) in November 2022, allowing closer to real-time participation of all players. Along with coupling within EU borders, Greece is making efforts to increase coupling through intraday auctions outside the European Union (Albania, North Macedonia and Türkiye). This will allow allocating the remaining day-ahead cross-zonal capacity to the market participants, who are expected to manage their market positions more efficiently closer to real-time delivery.

The balancing market needs to be further improved to fully align with the EU legal framework and reduce the balancing costs. According to an RAE decision, renewables will be able to participate as balancing service providers in the market from October 2022 (for manual frequency restoration reserve) and January 2023 (for automatic frequency restoration reserve). Further reforms in the balancing market are planned based on the draft market reform plan Greece submitted to the European Commission.

Forward market liquidity is still low. Suppliers have made little use of the forward market operated by the Hellenic Power Exchange. The limited hedging opportunities have left suppliers in Greece very exposed to the recent increases in wholesale electricity prices, which have been passed on to final consumers. More efforts will be needed to improve hedging opportunities for market participants. The government could consider introducing a requirement for retailers to cover a significant share of fixed-price contracts with long-term contracts. This could increase demand and liquidity.

Greece has increased its ambition on energy storage from 1.4 GW in 2022 to 3.5 GW by 2030 to help meet increased ambitions for renewable deployment. A law passed in

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June 2022 made changes to clarify and accelerate the licensing process for energy storage projects. It created clear legal and regulatory definitions for energy storage, including options for stand-alone storage and storage incorporated with renewable generation. The law expands the potential revenue streams for storage projects by giving them the right to participate in the intraday and balancing markets. The government needs to closely monitor the deployment of energy storage (especially battery storage) and take steps as needed to ensure that rapid deployment starts soon. Support schemes are needed to encourage the deployment of distributed storage.

Greece has completed a number of investments that connect islands to mainland Greece. Cross-border interconnections are also in the pipeline, like the second interconnection between Greece and Bulgaria and the Eurasia interconnector. Internal grid reinforcements are crucial for system security and further renewables penetration. Construction of new transmission lines, construction of new high-voltage and extra high-voltage substations, reinforcement of existing HV and EHV substations, reinforcement and rerouting of 150 KV grid are parts of the TSO's national Ten-year Development Plan.

For non-interconnected islands, Greece should conduct a cost-benefit analysis comparing the interconnection of islands with the deployment of storage on islands. Currently, Greece is planning to deploy both solutions (connection and storage) for most islands, which may not always be the most cost-effective solution for clean, secure and affordable electricity for all islands.

Legislation passed in 2019 calls for the creation of a new capacity remuneration mechanism that will award capacity payments through competitive auctions run by the TSO; however, the mechanism has not been implemented and may not be needed. More steps are required before such a mechanism is implemented, including a resource adequacy assessment followed by a state aid decision by the European Commission and an updated market reform plan. The annual market monitoring reports of the European Union Agency for the Cooperation of Energy Regulators and the Council of European Energy Regulators both indicate that Greece did not convincingly demonstrate that it had resource adequacy issues justifying the introduction of a capacity remuneration mechanism (ACER and CEER, 2022). Greece is encouraged to submit the final market reform plan to the European Commission, taking into account the recent energy developments following the Russian invasion of Ukraine.

Retail electricity markets

There have been positive steps in the development of competition in the Greek retail market, but PPC's market share is still substantial. High energy prices put additional pressure on small suppliers as well as risks that may lead to their exit from the Greek market. Greece has not yet fully transposed the EU rules on retail markets, in particular those on consumer empowerment and protection, aggregation, dynamic prices, and demand response.

Electricity bills are still complex and include separate charges for electricity, transmission and distribution charges, levies, taxes, and non-energy related charges such as television and municipality charges. The tax share of the electricity price decreased from 19.3% in 2017 to 11.9% in 2022, remaining an important part of the bill given the high energy prices. Greece should consider eliminating non-energy components from electricity bills.

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Greece has taken several measures since October 2021 to address the high energy prices to help households and small enterprises. The measures include subsidies to reduce electricity bills, a one-time fee on excess profits of electricity generators and caps on wholesale electricity prices. Greek authorities should closely monitor the impact of these measures on the wholesale and retail markets (notably for CCGTs) and adjust, where necessary, prioritising other measures with no regulated price elements (e.g. direct subsidies, tax reductions). The government should consider eliminating the tax on gas used for electricity generation. The tax seems intended to help reduce electricity bills, but it will most likely increase the cost of electricity, frustrating the intended goal.

Recommendations

The government of Greece should:

- Accelerate the pending reforms in the electricity sector to achieve the green energy transition in a just and cost-efficient way while maintaining security of electricity supply.
- Establish and implement the legal and regulatory frameworks for smart grids, energy storage, offshore wind and renewable hydrogen.
- Empower and protect consumers by completing the relevant legal and regulatory frameworks. Enable the participation of prosumers and demand response in the electricity markets by accelerating the necessary infrastructure, especially smart meters.
- Simplify electricity bills by removing all non-energy related costs.

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7. Natural gas

Key data

(2021)

Domestic production: 0.004 bcm of natural gas, -33% compared to 2011

Net imports: 6.4 bcm, +35% compared to 2011

Share of gas: 41% of electricity generation, 27% of total energy supply, 15% of heat generation, 9.7% of TFC

Domestic demand: 6.4 bcm, +38% compared to 2011

Demand by sector: electricity and heat generation 68.6%, industry 19.2%, residential buildings 9.2%, service sector buildings 2.6%, transport 0.4%

Overview

Natural gas is playing an increasing role in the Greek energy system. From 2011 to 2021, natural gas demand increased from 4.7 bcm to 6.4 bcm, driven mainly by a transition from lignite-fired generation to gas-fired generation, along with increased gas demand from industry and buildings. In 2021, natural gas covered 41% of electricity generation and 27% of TES. In 2021, gas covered 22% of industry energy demand, 11% of building energy demand and 9.7% of total final consumption (Figure 7.1). Greece has only limited domestic gas production, just 0.004 bcm in 2021, and most of the gas supply is imported.

The gas sector has undergone major changes since the IEA's last Energy Policy Review of Greece in 2017. The retail gas market was liberalised in 2018. A wholesale gas-trading platform was introduced, and a small but increasing share of gas supply is traded through the platform (5.6% in March 2022). DEPA, the state-controlled incumbent gas supplier that owned most gas infrastructure, was broken up into several companies, separating commercial supply activities from ownership of infrastructure, and there has been a notable increase in market competition.

The future of natural gas in the Greek energy system remains unclear, with major steps being taken to reduce gas demand in line with climate and security goals while at the same time, large investments are planned to expand gas infrastructure, which could lead to higher gas demand. The NECP and other planning documents give natural gas a major role in reducing emissions by substituting lignite-fired generation and expanding the gas network to reduce oil demand from building heating and industry. The government sees gas-fired generation as a key technology to support system balancing as lignite is phased

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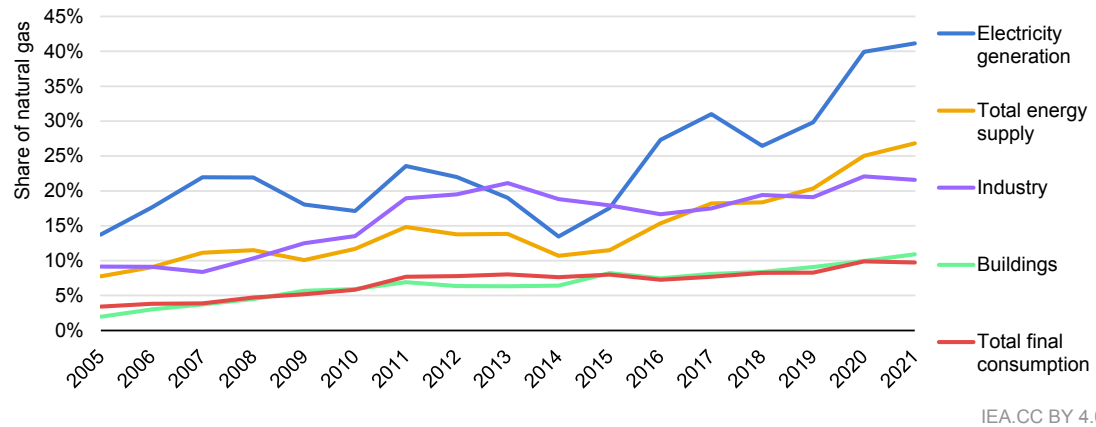
out and the share of variable generation from wind and solar PV increases. The NECP also calls for increased gas import and export capacity to promote Greece as a regional gas hub. The government has long-term goals for decarbonising the gas supply with hydrogen produced using renewable electricity and with biomethane.

Following the Russian invasion of Ukraine and the sustained increase in gas prices, the government is evaluating the role of gas in the energy system and taking steps to reduce reliance on Russian energy imports. These include steps to reduce gas demand in the short term, such as fuel switching at industrial sites and of stockpiling lignite, and measures to reduce long-term gas demand, including increased support for renewables and energy efficiency. The government indicates that Greece's reliance on Russian gas has been reduced from 40% to around 20% of supply in 2022 and that measures are in place to ensure gas supply if no gas is available from Russia.

Figure 7.1 Share of natural gas in Greece's energy system, 2005-2021



Source: IEA (2022a).

Gas demand, supply and trade

From 2011 to 2021, natural gas demand increased from 4.7 bcm to 6.4 bcm (Figure 7.2). This increase was driven by higher demand for gas-fired electricity (2.9 bcm to 4.4 bcm) caused by the phase-out of lignite-fired generation. Over this period, gas demand also slightly increased in the industry sector (from 1.17 bcm to 1.24 bcm) and in residential buildings (from 0.4 bcm to 0.6 bcm), while gas demand in service sector buildings remained relatively constant at around 0.2 bcm. The government had forecast an increase in natural gas demand in all sectors, with an expectation that total demand for natural gas could increase by 35% by 2030 compared to 2020. However, this forecast is under revision following the sharp increase in gas prices since the third quarter of 2021 and decisions to accelerate the deployment of renewables and energy efficiency measures. From January to September 2022, gas demand dropped by almost 15%, driven mainly by fuel switching in the industrial sector.

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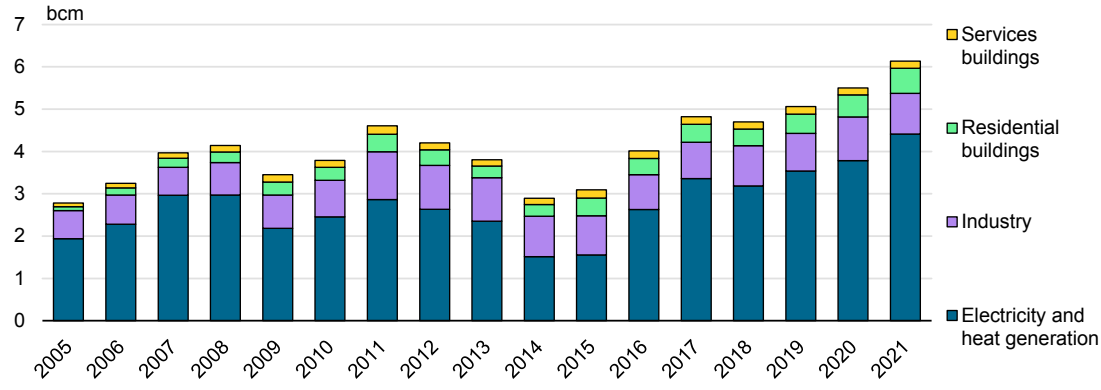
Figure 7.2 Natural gas demand by sector in Greece, 2005-2021



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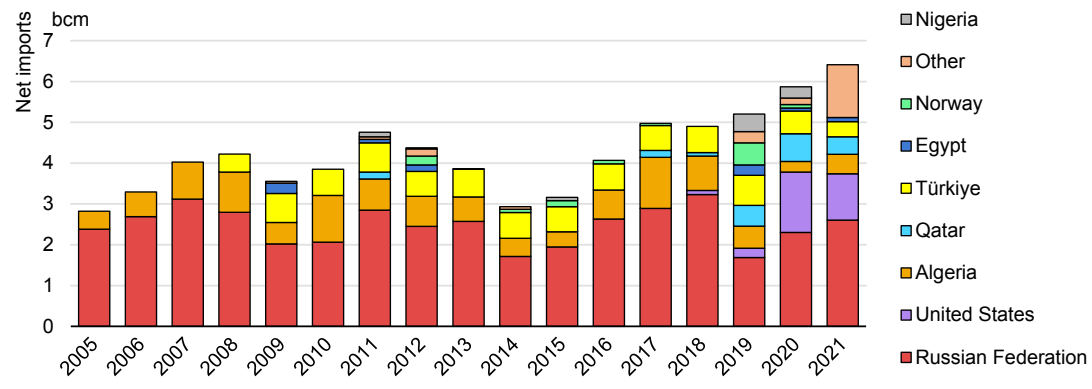
Source: IEA (2022a).

Greece has only marginal gas production and covers almost all gas demand with imports. From 2011 to 2021, Greece's gas net imports increased by 35%, from 4.8 bcm to 6.4 bcm (Figure 7.3). Imports from Russia via pipeline have historically accounted for most gas imports, ranging from 54% to 85% of imports between 2005 to 2018. The capacity of Greece's LNG terminal was expanded in 2018, supporting a notable increase in LNG imports (Figure 7.4). The increase in LNG capacity supported a diversification of imports and resulted in a notable reduction in the share of imports from Russia, which dropped to 41% (2.6 bcm) in 2021 and 17% (1 bcm) in 2022. Greece's LNG import capacity notably increased in August 2022 with the addition of a new floating storage unit.

The increased LNG deliveries and the start of commercial operations of a new pipeline interconnection to Bulgaria have led to a notable increase in gas exports, mainly to Bulgaria. Greece's gas exports to Bulgaria have increased from just 0.008 bcm in 2018 to 0.92 bcm in 2022. Gas exports to Italy increased from 6.9 bcm in 2021 to 9.7 bcm in 2022.

Greece's domestic gas production is small and has declined substantially from a peak of 0.036 bcm in 2002 to just 0.004 bcm in 2021 (compared to a gas demand of 5.8 bcm in 2020). Gas is produced from the offshore Prinos and South Kavala fields in northern Greece, with gas reserves in these fields estimated at 0.073 bcm. Most domestic gas production is either reinjected to boost oil production or used to meet energy demands at oil production sites. Greece has announced that it will take steps to increase domestic gas production to reduce reliance on Russian imports.

Figure 7.3 Greece's natural gas net trade by country, 2005-2021



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Source: IEA (2022a).

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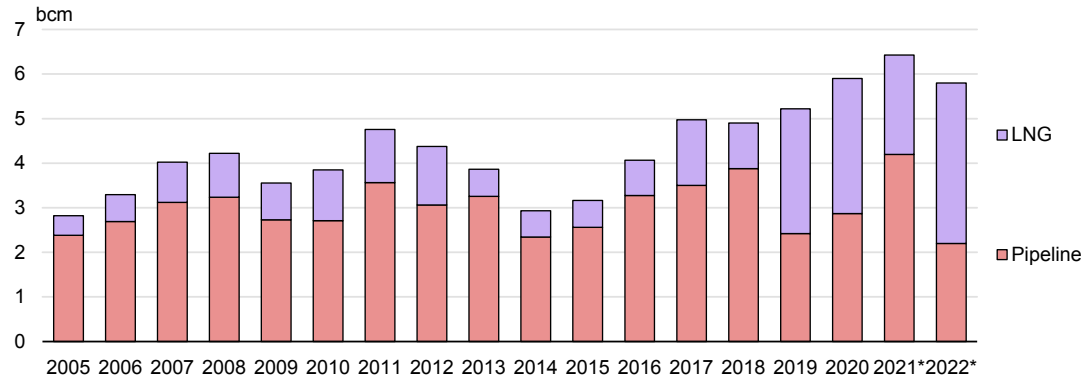
Figure 7.4 Greece's natural gas imports by source, 2005-2022



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* Data for 2021 are provisional and data for 2022 were provided by the Greek administration. Source: IEA (2022a).

Infrastructure

In 2022, there were three natural gas pipeline systems operating in Greece, each with separate entry-exit systems: the National Natural Gas Transmission System (NNGTS), the Trans-Adriatic Pipeline and the Interconnector Greece-Bulgaria (IGB) pipeline (Figure 7.5). The NNGTS is designed mainly to receive imports to meet domestic gas demand. The TAP runs through Greece from the border with Türkiye to Albania and then to Italy. The TAP is a major source of gas imports to Europe from Azerbaijan. The IGB, which started operating in October 2022, supports gas deliveries to Bulgaria. There are plans to connect the IGB to the NNGTS, but this requires the construction of a new compressor station in Greece that is expected to start operating in late 2024.

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Figure 7.5 Natural gas infrastructure in Greece

Import/export

In 2022, Greece's NNGTS had four entry points supporting gas trade. The largest is the Revithoussa LNG terminal, which was upgraded in 2018 and again in 2022 to increase import capacity to around 7 bcm. The Kipi cross-border pipeline interconnection supports imports from Türkiye. The Sidirokastro cross-border pipeline interconnection supports bidirectional flows between Greece and Bulgaria. The Nea Mesimvria entry point started operation in 2020 and connects the NNGTS to the TAP near Thessaloniki. In 2022, the Sidirokastro, Nea Mesimvria and Kipi entry points had a combined import capacity of around 5.4 bcm due to congestion issues on the northern part of the NNGTS. The TSO is planning to add two new compressor stations to remove these restrictions, which could increase total import capacity to 13.5 bcm.

There are several ongoing or planned projects aiming to develop additional LNG terminals to boost import capacity and allow for greater exports to neighbouring countries. In May 2022, construction started of a new floating LNG terminal located at Alexandroupolis in northern Greece. The EUR 360 million project aims to start operations in December 2023

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and will have 153 500 m^3 of storage capacity and 5.5 bcm of import capacity (Reuters, 2022a). The European Commission is providing EUR 167 million to support the project. The RAE has approved a licence for a EUR 300 million project to construct a floating LNG terminal near Corinth with a storage capacity of 210 000 m^3 and an import capacity of 2.5 bcm. The private project developer has indicated that the project could start operations in 2023. The RAE is evaluating a proposal for another floating LNG terminal in the gulf of Volos.

The gas TSO is also working to expand export capacity, which it estimates could reach 8.5 bcm in 2024 (versus 2.1 bcm in 2022). The gas TSO has plans for compression stations and other infrastructure to boost export capacity. In addition, Greece and North Macedonia are co-operating on the construction of a 123-kilometre interconnector pipeline from Nea Mesimvria in Greece to Negotino in North Macedonia. The pipeline is mainly intended to export gas to North Macedonia to support its diversification away from Russia and its transition away from coal-fired generation. The pipeline project has an estimated cost of around EUR 150 million, with funding from the European Investment Bank. The pipeline is expected to start operations in 2025, with a capacity 1 bcm.

Transmission

The NNGTS is operated by the gas TSO (DESFA) and consists of a 512 km main high-pressure pipeline and 975 km of high-pressure line branches. Under national law and the DESFA network code, third parties have non-discriminatory access to the transmission network. Third-party access tariffs are regulated by the RAE and consist of charges for entry and exit points. In 2019, the tariff methodology was harmonised with EU regulations that require a capacity-weighted distance tariff scheme. This scheme aims to avoid discrimination among users and for network tariffs to reflect real costs.

Distribution

Greece has a relatively limited gas distribution network, with only 8.3% of buildings having a natural gas connection. The distribution network primarily serves the population centres of Athens and Thessaloniki. In 2022, four gas DSOs were operating in Greece (EDA Attikis, EDA Thess, DEDA and HENGAS). EDA Attikis, EDA Thess and DEDA are owned by DEPA Infrastructure, which in 2022 was 100% acquired by the Italian DSO Italgas. EDA Attikis operates the distribution network in Attica. EDA Thess operates the distribution networks in Thessaloniki and Thessalia. DEDA develops and operates distribution networks in Sterea Ellada, Central Macedonia, Eastern Macedonia, Thrace and Corinth. DEDA has submitted a proposal for developing distribution networks in the areas of Epirus, West Macedonia and West Greece. It plans to develop new distribution networks to 34 cities. HENGAS was issued a licence by the RAE in 2020 to develop new distribution gas networks in nine areas of Greece and was certified and licenced as an ownership unbundled DSO in mid-2021.

Gas storage

Greece does not have any large-scale natural gas storage facilities. The limited storage capacity at the LNG terminal is used mainly for short-term LNG storage to support commercial operations. In June 2020, the government launched a two-stage international tender for the development of a natural gas storage facility in the depleted South Kavala gas field. The government estimates that the field could support 530 mcm of gas storage

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and operate two cycles per year at a peak withdrawal of 9 mcm per day. In 2021, the European Commission included this project under the fifth list of European Projects of Common Interest. However, there is an ongoing debate on the benefit of this project due to high costs and non-compatibility with government plans for hydrogen to play a key role in reducing natural gas demand (the field is most likely not capable of storing hydrogen).

Market structure

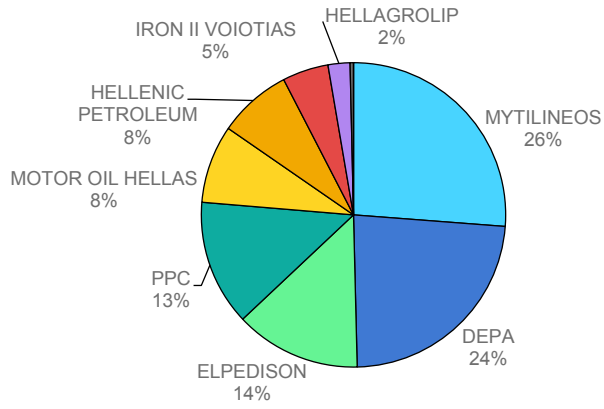
The Greek gas market has changed significantly since the IEA's last Energy Policy Review in 2017. In 2016, a single state-owned company, Public Gas Corporation S.A. (DEPA), had a dominant position across the gas sector, as it supplied around 90% of Greece's gas imports and owned the gas TSO, the gas DSOs and most gas infrastructure. The DSOs also acted as the sole retail gas supplier in their services area. As a result of ongoing initiatives to increase gas market competition, DEPA's market dominance has been significantly reduced. Under the terms of the EU bailouts received from 2010 to 2019, Greece is required to privatise a wide range of state-owned companies to increase market competition. This included privatising much of DEPA, which was broken up into several companies.

DEPA Infrastructure retains ownership of Greece's three main DSOs but is now 100% owned by the private Italian company Italgas. DEPA no longer owns the gas TSO (DESFA), which is now held 34% by the Greek state and 66% by SENFLUGA, a partnership owned by the Italian, Spanish and Belgian gas TSOs and the Copelouzos Group. DEPA Commercial, which retained DEPA's activities as a wholesale gas supplier, is owned by the Greek state (65%) and HELPE (35%), Greece's leading oil importer. The retail market was fully liberalised in 2018, which ended the monopoly on retail supply by three companies that had been unbundled from the regional DSOs in 2016.

Wholesale market

Competition in Greece's wholesale gas market has improved notably. From 2016 to 2020, DEPA's wholesale market share dropped from 90% to 24% as market reforms allowed numerous additional suppliers to enter the market (Figure 7.6).

Figure 7.6 Natural gas wholesale market share by volume in Greece, 2020



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Source: DESFA (2022).

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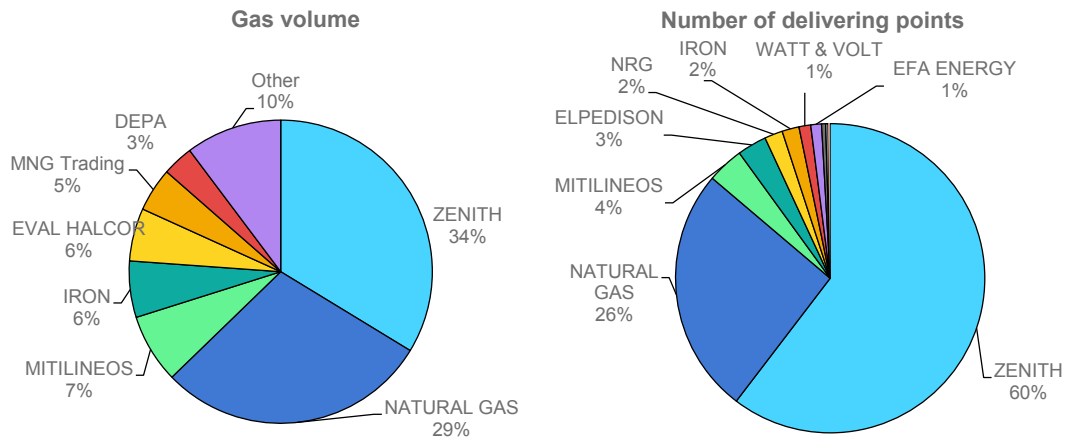
Trading in the wholesale segment of the gas market takes place on a platform operated by HEnEx. In 2022, the volume traded on the platform was 3.3% of the wholesale gas supply. Platform users trade gas without the pre-requisite of prior capacity booking at the natural entry/exit points. Trading is done daily for the following contracts; intraday and day-ahead for the next three days. The main trading method is continuous trading. Registration of pre-agreed trades is supported. Auctions and continuous trading between the TSO and market actors are possible for balancing purposes. The trading platform incorporates volatility control mechanisms and other functions for market protection purposes. Since March 2022, the trading platform has allowed anonymous trading (HEnEx, 2022).

Retail market

Greece's retail gas market was fully liberalised in 2018, when the monopoly on retail gas supply by EPA Thessaloniki/Thessaly and EPA Attica was abolished (these companies were created during the unbundling of commercial and network activities of the DEPA-owned DSOs in 2016). The retail gas supply companies ZENITH and NATURAL GAS, which resulted from the privatisation of EPA Thessaloniki/Thessaly and EPA Attica, respectively, have maintained dominant market positions based on the volume of retail sales and the number of connections (Figure 7.7). The HHI values for the retail gas market have improved, dropping from 6 453 in 2015 to 4 702 in 2018, with a strong drop following liberalisation to 2 317 in 2019, falling to 2 147 in 2020 and 2 079 in 2021. However, it should be noted that in their local areas, the incumbent in the Thessaloniki-Thessalia retains an 80% share market share, and the incumbent in Attika retains a 79% market share.[7]

Figure 7.7 Gas retail market share by company of gas customers in Greece, 2020



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Source: RAE (2020)

[7] The HHI is an indicator for market competition. It ranges between 0 for an infinite number of small firms (maximum competition) and 10 000 for one firm with a 100% market share (no competition). An HHI above 2 000 signifies a highly concentrated market with a small number of firms.

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Consumer switching rates are relatively low in Greece (Table 7.1). From 2019 to 2020, consumer switching rates decreased slightly due to the reduced switching of residential and commercial customers, while there was a slight increase based on the volume of consumption, related to the increased industrial consumers that switched.

Table 7.1 Customer switching rate by category in Greece, 2020

Customer category	Number of consumers	Volume
Households	3.48%	2.99%
Commercial	4.74%	7.67%
Industrial	4.32%	2.02%
TOTAL	**3.52%**	**3.30%**

Source: RAE (2020)

Prices and taxation

In 2Q 2022, natural gas industry prices in Greece were ninth-highest among IEA countries at 84 USD/MWh, with a tax rate of -28%, while the IEA average industry price which was 76 USD/MWh with an average tax rate of 5.5% (Figure 7.8). Household natural gas prices stood at 94 USD/MWh, with a tax rate of -5%, lower than the IEA average of 102 USD/MWh and a 17% tax rate.

Retail gas sales are subject to a reduced VAT (6% instead of 24%). Natural gas used for heating is subject to an excise duty of 1.1 EUR/MWh for households and 0.4 EUR/MWh for industry. Natural gas used for transportation or electricity generation is exempt from the excise duty. A supply security levy is also charged to natural gas consumers, with the rates calculated by the RAE. These levies are used to finance a security of supply account maintained by the gas TSO. This separate interest-bearing account covers costs relating to security of supply matters, mainly payments to large gas consumers (gas-fired power plants and industry) for voluntary demand reductions undertaken when there are gas supply concerns. The TSO is required to submit annual reports on the account to the RAE.

There have been increases in energy taxation to raise funding for programmes that reduce the impacts of high energy prices on consumers. In September 2022, a 10 EUR/MWh tax was imposed on gas used for electricity generation and a windfall profit fee was imposed on electricity generation, mainly from lignite, natural gas and large hydro.

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Figure 7.8 Natural gas prices in Greece for industry and households, 2Q 2022

Notes: Tax information is not available for Korea, Poland and the United States. Data for industry prices are unavailable for Australia, Japan, Mexico and Norway. Data for household prices are unavailable for Australia, Finland, Japan, Mexico and Norway.

Source: IEA (2022b).

Gas policy

The future of gas in the Greek energy system remains unclear, with major steps being taken to reduce gas demand in line with climate and security goals. At the same time, large investments are planned to expand gas infrastructure, which could lead to higher gas demand. Following the Russian invasion of Ukraine and sustained high gas prices, the government is re-evaluating the role of gas in the energy system and has taken numerous steps to ensure a secure supply of gas and to reduce gas demand through the increased deployment of renewables (see Chapter 4) and energy efficiency measures (see Chapter 3). There is also a strong focus on reducing the impact of high gas prices on consumers.

The NECP and other planning documents give natural gas a major role in reducing GHG emissions by substituting lignite-fired generation and expanding the gas network to reduce

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oil demand from building heating and industry. The government indicates that compressed natural gas and LNG will also play a role in reducing transport oil demand and is supporting the deployment of eight LNG refuelling stations and 55 compressed natural gas stations by 2030.

The government sees gas-fired generation as a key technology to support system balancing as lignite is phased out and the share of variable generation for wind and solar PV increases. The NECP calls for increased gas import and export capacity to promote Greece as a regional gas-trading hub. The government sees potential for trucking LNG to isolated gas networks fuelled by small-scale regasification plants.

Addressing the impacts of high gas prices

Starting in late 2021, global energy prices began to increase rapidly, especially in Europe. Price spikes and high volatility reached record levels in 2022, driven mainly by the impacts of the Russian invasion of Ukraine. The European benchmark gas price (TTF), which had never exceeded 30 EUR/MWh, reached an historic peak of almost 250 EUR/MWh in August 2022 and was 135 EUR/MWh in December 2022. From September 2021 to November 2022, Greece dedicated EUR 9 billion to energy subsidies and other measures to help consumers pay their utility bills. Most of this support is delivered through the Energy Transition Fund, established in 2021 to fund a variety of subsidies for electricity, natural gas and heating oil. The government has also made significant interventions in the wholesale electricity market to limit the impact of high natural gas prices, which are the main driver of increased electricity prices. From January to October 2022, state subsidies for natural gas paid from the Energy Transition Fund totalled around EUR 309 million.

In September 2021, the government established a one-time fee on profits earned by producers in Greece's wholesale electricity market (see Chapter 1). The revenue collected via the fee is directed to the Energy Transition Fund to reduce consumer bills. The fee is equal to 90% of the difference in gross profit from each month from 1 October 2021 to 30 June 2022 compared to the same month of the previous year, with certain adjustments. The fee will mainly affect generation from lignite, natural gas and large hydro, as it does not apply to most generation from renewables or co-generation.

Following the end of the one-time fee on profits in July 2022, the government introduced wholesale electricity market price caps. The caps for generation from natural gas and lignite are based on fuel costs and ETS allowance prices and are adjusted on a monthly basis. In December 2022, the price caps were 240 EUR/MWh for gas-fired generation and 200 EUR/MWh for lignite-fired generation. The price caps for large hydropower (112 EUR/MWh) and other renewables (85 EUR/MWh) are fixed. Any revenue electricity producers receive from prices above these caps must be given to the Energy Transition Fund to reduce consumer bills.

In September 2022, the government introduced a 10 EUR/MWh tax for gas used in gas-fired electricity generation. Revenue from the tax will go to the Energy Transition Fund to reduce consumer bills, to investments in biomethane and low-carbon hydrogen production projects, and to the expansion of natural gas infrastructure that helps end dependence on Russian gas. From January to October 2022, the subsidy was adjusted each month and ranged from 0 EUR /MWh to 40 EUR/MWh for households and 20-40 EUR/MWh for non-household consumers.

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Greek energy companies have also voluntarily taken steps to reduce consumer energy bills. Starting in October 2021 and throughout 2022, DEPA Commercial (one of the main natural gas suppliers) gave discounts ranging from 11 EUR/MWh to 90 EUR/MWh to its household consumers. DEPA started giving discounts up to 40 EUR/MWh to its non-household consumers starting in April 2022.

Reducing reliance on Russian gas imports

In 2021, 41% of Greece's natural gas imports came from Russia. In January 2022, just prior to the Russian invasion of Ukraine, DEPA Commercial signed a contract with Russia's Gazprom for around 2 bcm of gas per year until 2026 (Reuters, 2022b).

Shortly following the Russian invasion of Ukraine, Greece announced plans to boost import capacity at its LNG import terminal. A new floating storage unit started operations in August 2022. DESFA indicated that since the unit started operating, LNG cargoes have doubled year-on-year and that imports from Russia have dropped from 40% to less than 20% of Greece's gas supply. In September 2022, DEPA Commercial reached an agreement with TotalEnergies of France to secure LNG supplies in the event that imports from Russia are disrupted. The deal allows deliveries of two LNG cargoes each month through March 2023, which the government estimates could substitute almost 100% of Greece's gas imports from Russia.

There are several ongoing or planned projects to develop additional LNG terminals in Greece. Several of these projects were already under consideration before the Russian invasion of Ukraine but would help to further diversify Greece's gas imports and enable exports to neighbouring markets. The most advanced project, located at Alexandroupolis, started construction in May 2022. It should be operational by the end of 2023 and would almost double Greece's LNG import capacity.

Thanks to increased co-operation between Greece and Bulgaria following the Russian invasion of Ukraine, the IGB pipeline, which started construction in 2020 and, after several delays, was able to begin full commercial operations in October 2022. It brings gas from Azerbaijan and supports the diversification of Bulgaria's gas supply. Bulgaria had been receiving almost 100% of its gas supply from Russia until Gazprom cut off supply in April 2022. Bulgaria has also been importing gas through Greece's LNG. The government indicates that thanks to increased LNG import capacity and deliveries, gas exports to Bulgaria increased from just 0.0016 bcm in 2019 to 0.92 bcm in 2022.

Greece has announced that it will take steps to accelerate oil and gas exploration to reduce reliance on Russian imports. The state-owned company responsible for managing exploration and production concessions (HHRM) wants to conclude a first round of seismic surveys in 2023 to identify gas fields in one onshore and five offshore areas in western Greece and off the island of Crete. Energean, currently the only oil producer in Greece, aims to carry out test drilling at an onshore block in the west of the country, the first test drilling in Greece in 22 years. The Greek Prime Minister said the country aspires to become a significant gas producer and a hub for storage and transfers for the rest of Europe (Koutantou and Maltezou, 2022).

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In May 2022, the European Commission introduced the REPowerEU plan, which proposes numerous measures intended to end EU reliance on Russian energy imports while supporting energy transition. In October 2022, the Greek Ministry of Finance announced that it expected to receive EUR 8.7 billion of the REPowerEU funds, which will be directed to existing projects and reforms defined in Greece's recovery and resilience plan, with several of these programmes supporting a reduction in gas demand through increased deployment of renewable energy and energy efficiency measures.

Under the REPowerEU plan, the European Union adopted a natural gas storage obligation requiring that EU gas storage facilities be at least 80% full by 1 November 2022 and 90% full by 1 November in subsequent years. Greece is largely exempted from this obligation, as it has no large-scale gas storage facilities and limited interconnection capacity to member states with gas storage. However, Greece has agreed to store 100 mcm of gas (1.6% of Greece's annual demand). Under this arrangement, gas suppliers to the Greek market with shares above 1% will have an obligation to store part of the above quantity in Italy and Bulgaria pro rata to their market share, and the Italian gas TSO will have an obligation to make this gas available to Greece through commercial reverse flows in the TAP pipeline as well as the Bulgarian TSO directly to the Greek system. Greece also dedicates a small share of the LNG storage capacity to support emergency operations of gas-fired power plants.

In July 2022, EU member states agreed to voluntarily reduce their gas demand by 15% between 1 August 2022 and 31 March 2023, compared to their average consumption in the past five years. The regulation foresees the possibility for the European Commission to trigger a security of supply alert, in which case the gas demand reduction would become mandatory. Greece has already been taking steps to reduce its gas demand. From January to September 2022, gas demand dropped by almost 15% compared to 2021.

Prior to the Russian invasion of Ukraine, PPC (Greece's largest electricity utility, which owns most lignite-fired generation) was planning a notable increase in the capacity of gas-fired generation to support a rapid phase-out of lignite-fired generation from 2023 to 2025. To limit increased gas demand from electricity generation, the government and PPC announced in June 2022 that the phase-out of lignite-fired generation was being extended to 2028 (as required under the Climate Law). PPC also noted it would increase the extraction of lignite in 2022 from 10 Mt to 15 Mt, with the additional coal to serve as a security reserve in case disruptions in the deliveries of Russian gas cannot be covered by imports from other countries. PPC has also accelerated its investment in renewable energy projects to further reduce the demand for gas from electricity generation.

Hydrogen

The NECP notes a long-term potential to reduce gas demand and decarbonise gas supply through biomethane and hydrogen produced from renewable sources and indicates that Greece aims to develop hydrogen production based on renewable electricity, use hydrogen for decarbonising transport (mainly shipping) and long-term storage for electricity generation, and incentivise hydrogen-related research and innovation. The NECP includes goals to inject hydrogen (or biomethane) into the natural gas network and introduce a guarantee of origin system to stimulate the deployment of renewable hydrogen.

In December 2020, the MoEE established a special committee to produce a national hydrogen strategy to define a clear role for hydrogen production or use in Greece. The

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strategy is expected to be completed in 2023. A draft version of the strategy includes goals to deploy 750 MW of electrolysis capacity and produce 3 500 GWh of hydrogen using renewable energy by 2030. The draft indicates this would be supported by the deployment of an additional 3 GW of renewable generation (80% solar PV and 20% wind). The draft notes that hydrogen will mainly replace natural gas, along with some oil in the industry and transport sectors. The draft estimates that the desired level of hydrogen production would reduce GHG emissions by 0.75 Mt CO_2 (just 1.5% of total GHG emissions reduction required to reach the NECP emissions target) and reduce gas and oil imports by 10% each (500 ktoe or 21 PJ). The draft indicates that this would require investing EUR 3-4 billion to develop a domestic hydrogen supply chain, which would create an estimated 3 000-4 000 jobs and increase GDP by up to EUR 1.1 billion annually.

Greece supports the EU-wide target of producing 10 Mt of clean hydrogen by 2030. In December 2020, Greece signed a hydrogen manifesto with 22 other EU member states to participate in hydrogen Important Projects of Common European Interest (IPCEI). In July 2022, the European Commission approved the creation of the Hy2Tech IPCEI to support research, innovation and industrial deployments in the hydrogen technology value chain. The IPCEI was jointly prepared by 15 EU member states (including Greece) and will provide up to EUR 5.4 billion in public funding to 35 companies participating in 41 projects, which is expected to unlock an additional EUR 8.8 billion in private investments.

In September 2022, the European Commission approved the creation of the IPCEI Hy2Use to boost the supply of renewable and low-carbon hydrogen. The IPCEI was jointly prepared by 13 EU member states (including Greece) and will provide up to EUR 5.2 billion in public funding to 39 companies participating in 29 projects, which is expected to unlock an additional EUR 7 billion in private investments. One project in Greece was selected for funding. The H2CEM project will receive EUR 60 million to support hydrogen production through electrolysis powered by renewable energy sources at three cement plants in Greece. The operator of the plants estimates the H2CEM project will reduce CO_2 emissions by 0.16 Mt per year, equal to a reduction of at least 8% per tonne of cement.

Gas security

Natural gas is an important fuel for maintaining energy security in Greece, especially in the electricity sector. Gas-fired plants account for the largest share of electricity generation (41% in 2021) and play a key role in system balancing and the security of electricity supply. Gas is also a key fuel for industry, covering 22% of industry energy demand in 2020. Gas plays a relatively limited role in buildings, covering just 10% of building energy demand in 2020. However, in certain areas of Greece, gas is a key fuel for home heating. Greece relies mainly on market forces to ensure a secure gas supply. However, Greek energy policy defines additional measures that can be taken to ensure the security of gas supply in the event of a supply disruption.

The RAE is responsible for implementing EU Regulation 2017/1938, which aims to ensure that all the necessary measures are taken to safeguard an uninterrupted supply of gas throughout the European Union, especially for protected customers, in the event of difficult weather conditions or disruptions of the gas supply. In line with this regulation, the RAE assesses risks to gas security and develops preventive action plans that detail steps to reduce these risks. The RAE also approves the emergency plan developed by the gas TSO, which details the steps to be taken in response to a disruption in gas supply. The

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latest emergency plan was submitted to the European Commission in November 2022, the latest risk assessment was conducted in May 2020 and the latest preventative action plan was approved in August 2022.

Under the current emergency plan, the declaration and management of a gas supply emergency would be co-ordinated between the Crisis Management Unit, the Crisis Management Group and the Emergency Measures Coordination Committee. The emergency plan defines three levels of crisis: 1) early warning; 2) alert; and 3) emergency. It also defines the role and responsibilities of the gas TSO and DSOs, the RAE, relevant government authorities, and gas market participants at each crisis level.

The emergency plan details a variety of measures to be taken in the event of a crisis. Supply-side measures are relatively limited as Greece has small domestic gas production and no large-scale gas storage. Under a Level 2 or 3 crisis, the TSO is authorised to take steps to increase import capacity at available entry points to ensure that the system can deliver the maximum technical capacity of gas. The LNG terminal plays a key role in maintaining gas supply security. LNG storage capacity is used to maintain an LNG security reserve for electricity generation. The amount of LNG security reserves is calculated for each obligated holder of an electricity generation licence and must cover 16 hours per day for 5 days for each power plant. For the winter of 2021/22, the LNG security reserve totalled 67.2 m^3 of LNG (around 0.04 mcm of natural gas). For the winter of 2022/23, the LNG security reserve totalled 85.1 m^3 of LNG (around 0.05 mcm of natural gas). To ensure secure 24-hour operations, the LNG terminal has an onsite co-generation unit and, as a backup, can be supplied through two independent 20 kV distribution lines, each of which is able to fully meet the electricity demand of the terminal.

Measures to reduce gas demand play a key role. In case of a gas supply crisis, the security of electricity supply is supported by five gas-fired power plants that can switch from natural gas to diesel. These plants are obligated to ensure uninterruptible operation using diesel for at least 5 days under partial load and must keep the needed level of diesel stored onsite. These plants have a total generation capacity of 2.0 GW when fuelled with gas and 1.8 GW when fuelled with diesel (compared to Greece's peak demand of 8.6 GW in 2020).

Imposed interruption/limitation of gas supply to consumers is the key measure to ensure the reliable and safe operation of the gas system during a Level 3 gas crisis and to limit impacts on protected consumers (households, essential social services, SMEs) and electricity generation. The emergency plan defines the order for imposing interruption/limitation of gas supply, which starts with industrial consumers with demand above 100 GWh, followed by industrial consumers with demand equal to or less than 100 GWh and then commercial consumers that are not protected consumers. Any natural gas supplier that provides natural gas directly or indirectly to protected consumers is obliged to take all the necessary measures to ensure the uninterrupted supply of natural gas to these consumers.

The emergency plan also allows for interruptible contracts between consumers and suppliers that provide a payment to consumers who agree to have their gas supply reduced in case of a crisis. However, no consumers have signed such a contract.

Greece's preventive action plan indicates that the implementation of existing demand reduction measures would reduce gas demand by 9.6 mcm/day, with 8.6 mcm/day coming from fuel switching at power plants and 1.1 mcm/day from interruption/limitation of gas supply to consumers. Even with these measures, Greece does not meet the N-1

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requirement for security of gas supply for the 2021/22 gas year; the N-1 scenario would allow only 84% of gas demand to be covered. The N-1 scenario estimates a loss of supply if the largest single piece of critical infrastructure stops working; in Greece, this is the LNG terminal. Under EU Regulation 2017/1938 on gas security, neighbouring EU member states can agree on the joint obligation to comply with the N-1 infrastructure standard. In line with this, Greece participates in several risk groups that examine options for ensuring supply in a crisis. For 2020 and 2021, it was shown that, in most cases, regional co-operation would meet the N-1 requirement.

Assessment

Natural gas is playing an increasing role in the Greek energy system, driven mainly by a transition from lignite-fired generation to gas-fired generation, along with increased gas demand from industry and buildings. Gas-fired power plants are the largest source of electricity generation (41% in 2021) and play a key role in system balancing and maintaining security of electricity supply. Gas is also an important fuel for industry and, in some areas of Greece, an important source of building heating. Greece has only limited domestic gas production, just 0.004 bcm in 2021, and most of the gas supply is imported, with Russia being the largest supplier (41% of gas imports in 2021).

The future of gas in the Greek energy system remains unclear, with major steps being taken to reduce gas demand in line with climate and security goals while at the same time, large investments are planned to expand gas infrastructure, which could lead to higher gas demand. The government has indicated it would like Greece to become a regional gas hub. Following the Russian invasion of Ukraine and sustained high gas prices, the government is evaluating the role of gas in the Greek energy system and has taken numerous steps to ensure a secure supply of gas and to reduce gas demand through increased deployment of renewables and energy efficiency measures. There is also a strong focus on reducing the impact of high gas prices on consumers.

The IEA commends Greece for its steps to reduce national and regional reliance on Russian gas imports. Thanks to rapid investments in expanded LNG capacity, Greece has been able to reduce Russian gas imports from 40% to 20% of its gas supply and put in place LNG contracts to fully meet gas demand if Russia stops supplying gas. Thanks to improved co-operation with Bulgaria, the IGB pipeline, which was under construction for several years and faced notable delays, started commercial operations in October 2022, helping to reduce Bulgaria's dependence on gas from Russia.

Greece has also taken steps to reduce gas demand in both the short term (fuel switching by large consumers) and the long term (major increases in funding and simplification of procedures for permitting of renewable energy and energy efficiency projects). Greece does not have large-scale gas storage but has secured the use of some gas storage in Italy and is reserving some LNG storage capacity for response to supply emergencies. The government is also examining options for increasing the thus far limited domestic gas production.

However, the government needs to make a stronger effort to determine whether further gas infrastructure should be developed, balancing immediate concerns over energy security with the need to reduce gas demand and associated GHG emissions and considering the risks stemming from gas price volatility and stranded assets. Notably,

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expanding the gas distribution network should be reconsidered, as there are clear alternatives to meet energy demand through electrification, renewable energy and improved building energy efficiency. The government should also clarify the expected role of hydrogen and biomethane in decarbonising gas supply, with a priority placed on hard-to-abate sectors and end uses. Given the seasonality of economic activity and lack of industry on most of Greece's islands, bringing gas to the islands does not make economic sense and would undercut Greece's overarching climate goals.

The IEA commends Greece for the notable progress in developing its natural gas market. The gas sector has undergone major changes since the IEA's last Energy Policy Review of Greece in 2017, with a strong increase in competition in the wholesale and retail markets. DEPA, the state-controlled incumbent gas supplier that owned most gas infrastructure, was broken up into several companies, thereby separating commercial supply activities from ownership of infrastructure. Greece successfully introduced a trading platform for the wholesale gas market, which has been progressively expanded to offer more products. In March 2022, the volume traded on the platform reached 5.6% of the wholesale gas supply. The retail gas market, which was liberalised in 2018, has seen growing competition, with the HHI dropping from 6 453 in 2015 to 2 317 in 2019.

Although promising, the first results of market opening are too premature to assess the longer term impacts, and there is still notable room to improve competition in the gas market. At the wholesale level, just seven companies accounted for 98% of supply in 2020, with the two largest ones covering 50% of supply. At the retail level, two suppliers that resulted from the privatisation of the incumbent DSOs have maintained dominant market positions based on the volume of retail sales (63% in 2020) and the number of connections (86%). In addition, the switching rate for retail consumers has remained relatively low. The plan to introduce long-term products on the wholesale trading platform should be accelerated.

In addition, creating a transparent secondary market for import capacity (for instance, via an open booking platform) would lead to more effective utilisation of import infrastructure and enhance competition among wholesale market players.

In September 2022, the government introduced a 10 EUR/MWh tax for gas used in gas-fired electricity generation. Revenue from the tax will go to the Energy Transition Fund to reduce consumer energy bills and will also support investments that help end dependence on Russian gas. The government should consider eliminating the tax on gas used for electricity generation. The tax seems intended to reduce electricity bills, but it will most likely increase the cost of electricity, defeating the intended goal.

Recommendations

The government of Greece should:

- ☐ Enhance energy security by diversifying gas supplies by origin and path of delivery, and by reducing gas demand through increased deployment of renewables and energy efficiency.

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- Reconsider the planned expansion of gas infrastructure based on analysis that identifies the most cost-efficient way to decarbonise energy demand while avoiding stranded assets and supporting energy security.
- Enhance market functioning by creating a trading platform for gas futures so market participants can hedge risk. Also, create a transparent secondary market for booked import capacity.

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8. Oil

Key data

(2021)

Net imports of crude oil:* 565 kb/d, +58% since 2011

Domestic oil products production: 639 kb/d

Net exports of oil products: 343 kb/d, +513% since 2011

Share of oil: 1.2% of energy production, 47% of TES,** 8.5% of electricity generation, 52% of TFC, 95% of transport, 36% of industry and 21% of buildings

Oil consumption by sector: 268 kb/d (domestic transport 44.2%, industry including non-energy consumption 17.3%, buildings 11.9%, electricity and heat generation 8.1%, international bunkering 18.5%)

* Note: "imports/exports of crude oil" includes crude oil, natural gas liquids and feedstock.

** Total energy supply does not include oil used for international bunkering.

Overview

The share of oil in Greece's energy supply and demand has decreased since 2005, but oil still accounted for 52% of TFC in 2021 and 47% of TES in 2021 (Figure 8.1). In 2021, oil covered almost all transport energy demand (95%), and significant shares of energy demand in industry (36%), buildings (21%) and electricity generation (8.5%). Imports cover almost all of Greece's crude oil supply (99% in 2021); however, there is limited domestic crude oil production (1.2% of supply). Greece is a net oil products exporter, with oil products output more than double the domestic demand in 2021.

Greece's energy policy is focused on maintaining security of oil supply while reducing demand for oil in line with GHG emissions reduction targets and protecting consumers from high energy prices. The government has implemented measures to support the uptake of EVs, the use of biofuels and a modal shift away from private vehicles. Oil-fired heating systems cannot be installed after 2025, and there is support to transition to other heating systems. Oil-fired electricity generation, which is used mainly in non-interconnected islands, will be reduced through electricity connections to the mainland and the deployment of renewables.

Following the Russian invasion of Ukraine, the European Union imposed sanctions banning seaborne imports of Russian crude oil (which started on 5 December 2022) and Russian oil product imports (which started on 5 February 2023). These bans ended Russian imports to Greece, as these imports were only delivered by ship. Greece's

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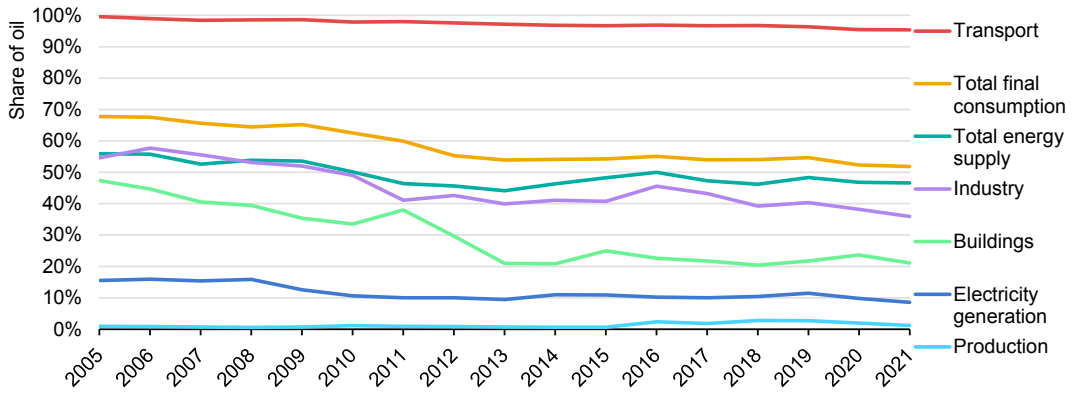
refineries have secured contracts to replace the imports from Russia with supplies from other countries. There are also efforts to increase domestic oil production.

Figure 8.1 Shares of oil in Greece's energy sector, 2005-2021



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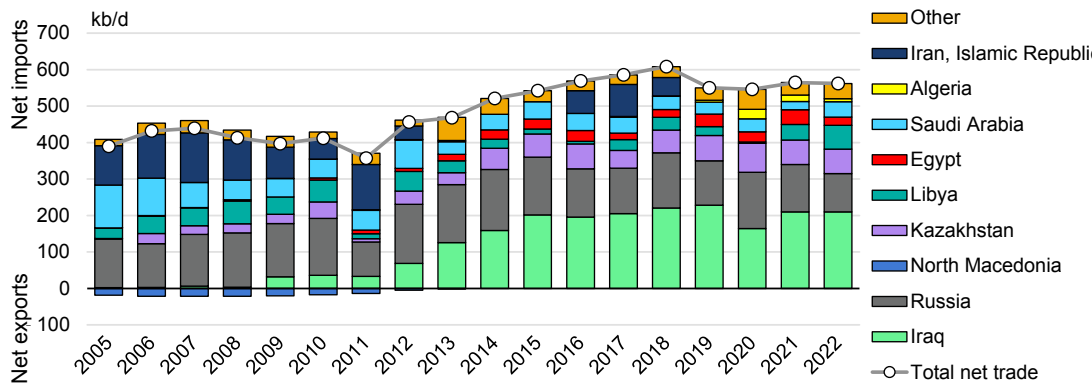
Source: IEA (2022a).

Crude oil supply

Almost all of Greece's crude oil supply is imported (99% in 2021). Greece has only small domestic production, just 1 kb/d and less than 1.2% of crude oil supply in 2021. Greece's net imports of crude oil were 565 kb/d in 2021 and came from Iraq (210 kb/d), Russia (130 kb/d), Kazakhstan (67 kb/d), Libya (43 kb/d), Egypt (40 kb/d), Saudi Arabia (23 kb/d) and Algeria (18 kb/d). Greece imported a significant amount of oil from Iran until 2018, when sanctions were imposed on Iranian crude oil exports. Crude imports from Russia ended on 5 December 2022, with the start of an EU-wide ban on Russian crude oil imported via shipping. Greece exports only a small amount of crude oil (just 1.7 kb/d in 2021).

Figure 8.2 Greece's crude oil net imports by country, 2005-2022



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Source: IEA (2022a).

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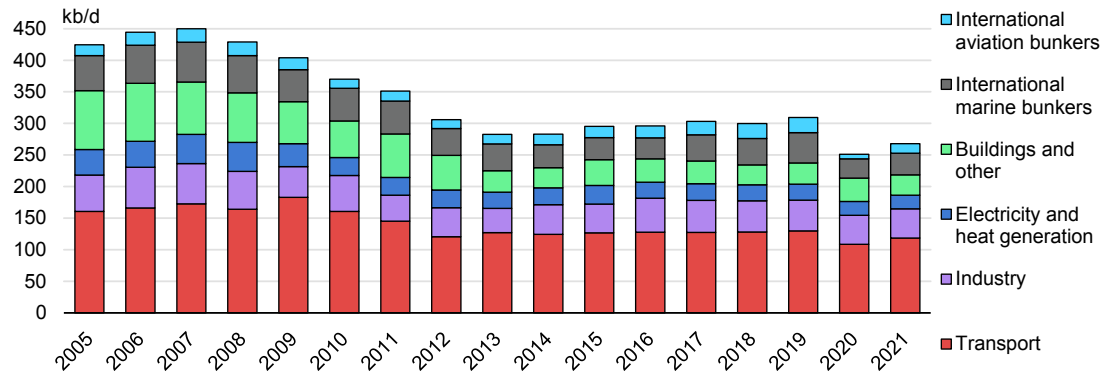
Oil products supply, demand and trade

From 2007 to 2013, Greece's oil product demand decreased significantly from 450 kb/d to 283 kb/d, with demand falling in all sectors (transport, industry and buildings) due to a strong contraction in overall economic activity (Figure 8.3). In line with improving economic conditions, oil products demand started increasing in 2014 to reach 309 kb/d in 2019. As a result of the Covid-19 pandemic, oil products demand dropped sharply to 251 kb/d in 2020, primarily because of reduced demand from transport (130 kb/d in 2019 to 108 kb/d in 2020), marine bunkers (48 kb/d to 31 kb/d) and aviation bunkers (24 kb/d to 7.5 kb/d). With the easing of the pandemic restrictions, total oil products demand rebounded again to 268 kb/d in 2021. The transport sector accounts for the highest share of oil products demand (44.2% in 2021), followed by international bunkers (18.5%), industry (17.3%), buildings (11.9%), and electricity and heat generation (8.1%). Within the transport sector, most demand comes from road transport (88%), followed by domestic navigation (9.5%) and aviation (2.7%).

Figure 8.3 Oil products demand by sector in Greece, 2005-2021



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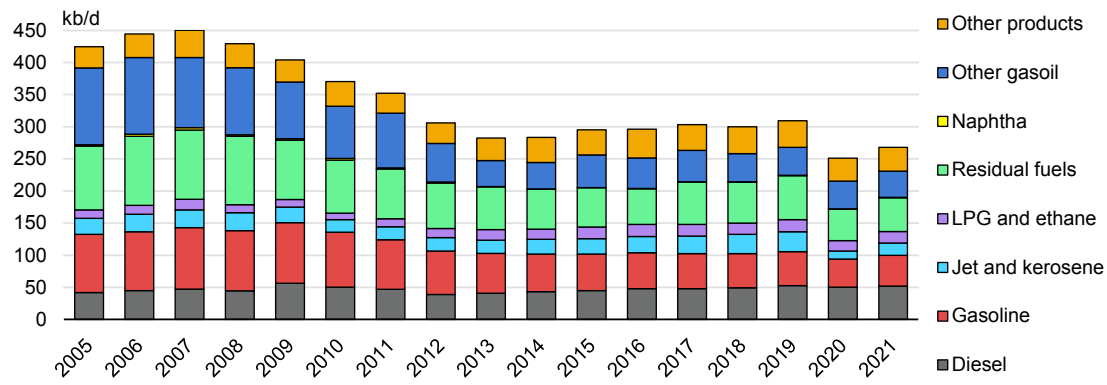
Source: IEA (2022a).

Demand for each oil product has changed in line with overall economic trends and shifting demand in each sector (Figure 8.4). From 2007 to 2021, demand increased for diesel (+10%), LPG and ethane (+8%) while it dropped for naphtha (-80%), gas oil products other than diesel (-63%), residual fuels (-51%), gasoline (-50%), and jet fuel and kerosene (-30%).

Figure 8.4 Oil products demand by product in Greece, 2005-2021



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Source: IEA (2022a).

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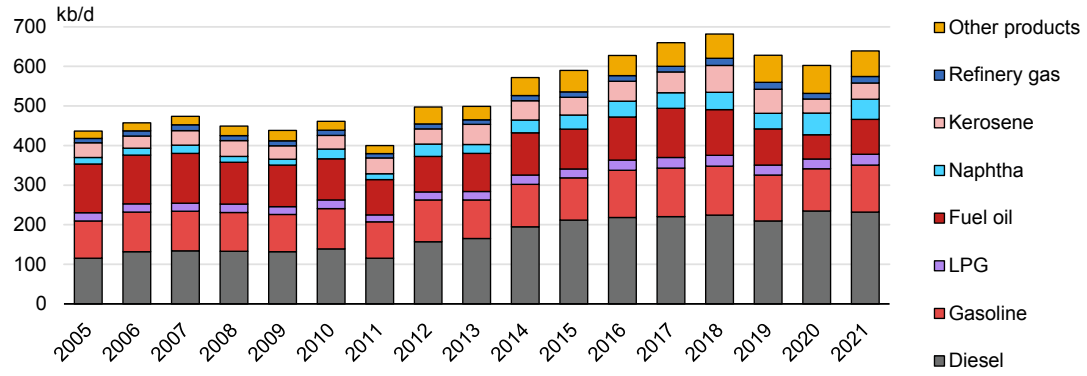
From 2011 to 2021, total domestic oil products demand experienced an overall decline, from 351 kb/d to 268 kb/d (-24%). At the same time, an increase in refinery capacity led to increased domestic oil products production, which grew from 400 kb/d in 2011 to 639 kb/d in 2021 (+60%), with a peak of 682 kb/d in 2018 (Figure 8.5). From 2011 to 2021, there was an increase in the production of diesel (+116 kb/d), naphtha (+36 kb/d), gasoline (+27 kb/d), LPG (+10 kb/d), refinery gas (+5 kb/d), and jet and kerosene (+1 kb/d), and a slight decline in the production of fuel oil (-1 kb/d).

Figure 8.5 Oil products production by product in Greece, 2005-2021



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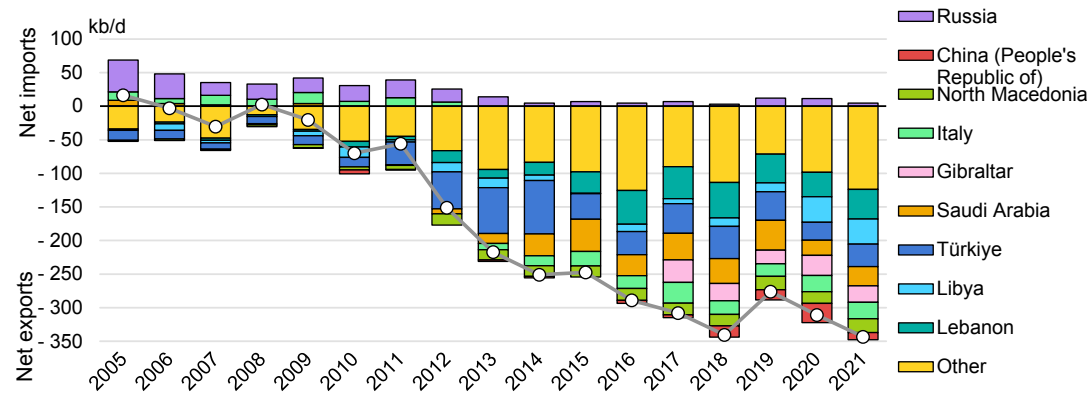
Source: IEA (2022a).

In line with falling domestic demand and increasing domestic production, Greece has seen a notable rise in oil product exports (Figure 8.6). From 2011 to 2021, net oil product exports increased from 56 kb/d to 343 kb/d (+513%). Greece has little net imports from Russia (4.5 kb/d in 2021), but these ended in February 2023, when the EU ban on imports of Russian oil products enters into force.

Figure 8.6 Greece's oil products net exports by country, 2005-2021



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Source: IEA (2022a).

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Infrastructure

Greece's oil sector infrastructure is composed of four oil refineries, two major ports (one near Athens and one near Thessaloniki) that support crude oil imports and oil product imports and exports, one crude oil pipeline (which links the refinery in North Macedonia to the port in Thessaloniki), one oil products pipeline (which links the Athens airport to refining capacity), and storage sites for crude oil and oil products. Greece has one active crude oil production area, the offshore Prinos concession (Figure 8.7).

Refineries

Greece has four oil refineries, with a total distillation capacity of 669.6 kb/d in 2020 (Table 8.1). Hellenic Petroleum (HELPE) owns three refineries (Aspropyrgos, Elefsina and Thessaloniki) with a combined capacity of 424.6 kb/d. Motor Oil owns the largest refinery (Korinthos), with a capacity of 245 kb/d. In 2021, the four refineries produced 634 kb/d of oil products.

In 2019, the Aspropyrgos refinery made investments so it can produce oil products that comply with the International Maritime Organisation (IMO) regulation, IMO 2020. Under IMO 2020, which entered into force on 1 January 2020, ships operating outside designated emission control areas must use fuels with sulphur content below 0.5%, a significant reduction from the previous 3.5% limit. The Elefsina and Thessaloniki refineries do not produce high-sulphur fuel oil, so no adjustments were required to their operations. Also in 2019, the Aspropygros refinery began producing bioether, which is helping to meet the updated requirement of Greece's biofuel blending obligation (see Chapter 4).

The most significant project at the Korinthos refinery is a new naphtha treatment complex, consisting of three new process units (a naphtha hydrotreater, a platforming unit and an isomerisation unit) and an upgrade of the existing utilities, which is expected to have a capacity of 22 kb/d. Another project at the same refinery is the new refinery mooring project, including the installation of a 1 MW battery system in late October 2021, which is expected to give the refinery more flexibility and the ability to serve oil tankers with a capacity of over 300 000 deadweight tonnes.

Table 8.1 Oil refinery capacity in Greece, 2020

Refinery	Owner	Capacity, kb/d
Korinthos	Motor Oil	245.0
Aspropyrgos	HELPE	201.4
Elefsina	HELPE	145.3
Thessaloniki	HELPE	77.9
Total capacity		**669.6**

Note: Capacity refers to the distillation capacity of the refineries (atmospheric and vacuum).

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Figure 8.7 Oil infrastructure in Greece, 2021

Ports

Greece has two major oil ports, one near Athens with seven terminals and one near Thessaloniki with three terminals. These ports are used mainly to receive crude oil imports for delivery to nearby refineries and to load oil products for exports and domestic distribution.

Transportation

Greece has two major oil pipelines. A 220-kilometre oil products pipeline with a capacity of 42 kb/d links the port of Thessaloniki with the Okta refinery in North Macedonia. A 53-kilometre oil products pipeline with a capacity of 30 kb/d delivers jet fuel from the Aspropyrgos refinery to Athens International Airport. In addition, numerous smaller crude oil and oil products pipelines support the commercial operations of the refineries, oil ports and oil storage facilities. Oil products from Greece's refineries are also transported for domestic distribution and export via ship, road and rail. There are no plans to develop additional large-scale oil pipelines in Greece.

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Storage

In 2021, Greece had 10 large-scale oil storage facilities, with a total oil storage capacity of around 60 mb (20 mb of crude oil and 40 mb of oil products). Most crude oil and oil products storage facilities are located near the ports and refineries in the Athens and Thessaloniki areas. The largest storage facilities are located at the Elefsina refinery (18.7 mb), at Agioi Theodoroi (14.7 mb, associated with the refinery of Korinthos owned by Motor Oil), at the Aspropyrgos refinery (around 8.7 mb), at Megara (6.9 mb, connected by pipelines with the refineries of Aspropyrgos and Elefsina owned by Hellenic Petroleum), and at the Thessaloniki refinery (6.8 mb). There are also large oil products storage facilities at strategic locations across the mainland and on the islands to support oil products distribution.

Production

In 2021, Greece had one active area for domestic crude oil production, the Prinos concession, located east of Thessaloniki. It is operated by Energean and consists of three offshore fields (Prinos, Prinos North and Epsilon). From 2016 to 2020, annual production from these fields ranged between 0.6 mb and 1.4 mb (less than 1% of Greece's crude oil supply).

Since the IEA's last Energy Policy Review in 2017, the HHRM has granted eight new exploration concessions; however, only one of these concessions has made progress towards production. In 2017, the government approved a development plan from Energean for the West Kavakolo concession located off the western coast of the Peloponnese. Since the Russian invasion of Ukraine, the government has expressed an increased interest in boosting domestic oil and gas production.

In 2019, Greece banned shale oil and gas production, and new developments cannot use fracking techniques.

Market structure

Greece's markets for crude oil and oil products are fully liberalised, with prices set by market forces. The government has the authority to set maximum retail prices on oil products at the local or national level in order to face the unfavourable consequences in the Greek economy that may be caused by the increased global crude oil prices or unjustifiably. The maximum price setting was last used in 2011. Since the IEA's last Energy Policy Review in 2017, Greece has taken steps that increased competition at the wholesale and retail levels. However, the oil markets still have a relatively high level of market concentration and limited competition.

Crude oil

Greece's two refining companies (HELPE and Motor Oil) purchase crude oil on the international market from a diverse range of suppliers. Russia was a significant source of crude oil supply to Greece (22% in 2021), but crude oil imports from Russia ended in December 2022 when the EU ban on Russian crude imports via ship entered into force. Greece receives all of its crude oil imports via ship. Both HELPE and Motor Oil have signed contracts to secure crude supplies from other countries to compensate for the loss of Russian imports.

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Oil products wholesale market

From 2016 to 2020, around 50 companies were active in the Greek wholesale oil market. However, over this period, a limited number of large suppliers maintained a dominant position, with only small changes in their market shares. In 2020, nine companies had a combined market share of 83%, while the largest supplier had a market share of 29%. The government is taking steps to improve wholesale competition, including a 2016 law that, among other changes, reduced the minimum capital and storage capacity required to receive a wholesale licence.

The holders of wholesale licences must regularly notify the Minister of Development and Investments and the RAE about their prices. The holders of refining and biofuels licences must notify the same authorities on how they set prices.

Oil products retail market

In 2019, Greece had around 6 500 licenced retail service stations; however, only around 5 700 of these stations were in operation. This shows a continuing decline in the number of retail stations, from around 7 500 in 2016 and 8 500 in 2008. However, Greece still has a relatively high number of retail stations per capita compared to the rest of Europe. This reflects the distribution of Greece's many islands and the scattered population living in isolated mountainous regions. In 2020, just six companies owned 76% of retailing fuelling stations, with one company owning 27%.

The holders of retail licences are obliged to post the prices of oil products sold at retail service stations on the website of the Observatory of Liquid Fuel Prices (http://www.fuelprices.gr) every time prices change or at least once every week.

Prices and taxation

Oil products are subject to a VAT of 24% and an excise duty (Table 8.2). There are numerous reductions and exemptions for the excise duty on oil products depending on the sector/end use. Oil products used for domestic marine shipping, ferries and fishing and for domestic aviation are exempt from excise duties. Diesel used for heating between 15 October and 30 April is subject to a reduced excise duty. Automotive diesel is charged a lower tax rate than gasoline, with the intention of reducing the cost of commercial road freight. Biofuels are taxed at the same rate as the equivalent fossil transport fuel.

A supply security levy is charged to importers of crude oil and oil products destined for domestic consumption or refineries. These levies are calculated as 1.2% of the refinery price for the relevant crude or product, and finance a fund used to maintain Greece's strategic oil reserves required under agreements with the IEA and the European Union.

Table 8.2 Excise duty by fuel excluding value-added tax in Greece, 2022

	Sector/end use	Value	Unit	EUR/GJ*
Heavy fuel oil	Heating	38	EUR/tonne	0.93
Light fuel oil	Heating	0.28	EUR/litre	7.29
Diesel	Automotive/heating	0.41	EUR/litre	11.20
	Winter heating**	0.28	EUR/litre	7.65
Gasoline	Automotive	0.7	EUR/litre	21.11
LPG	Automotive	430	EUR/tonne	9.35
	Heating	60	EUR/tonne	1.30

* Estimate based on: heavy fuel oil 40.68 GJ/tonne, light fuel oil 0.038 GJ/L, diesel 0.037 GJ/L, gasoline 0.033 GJ/L.

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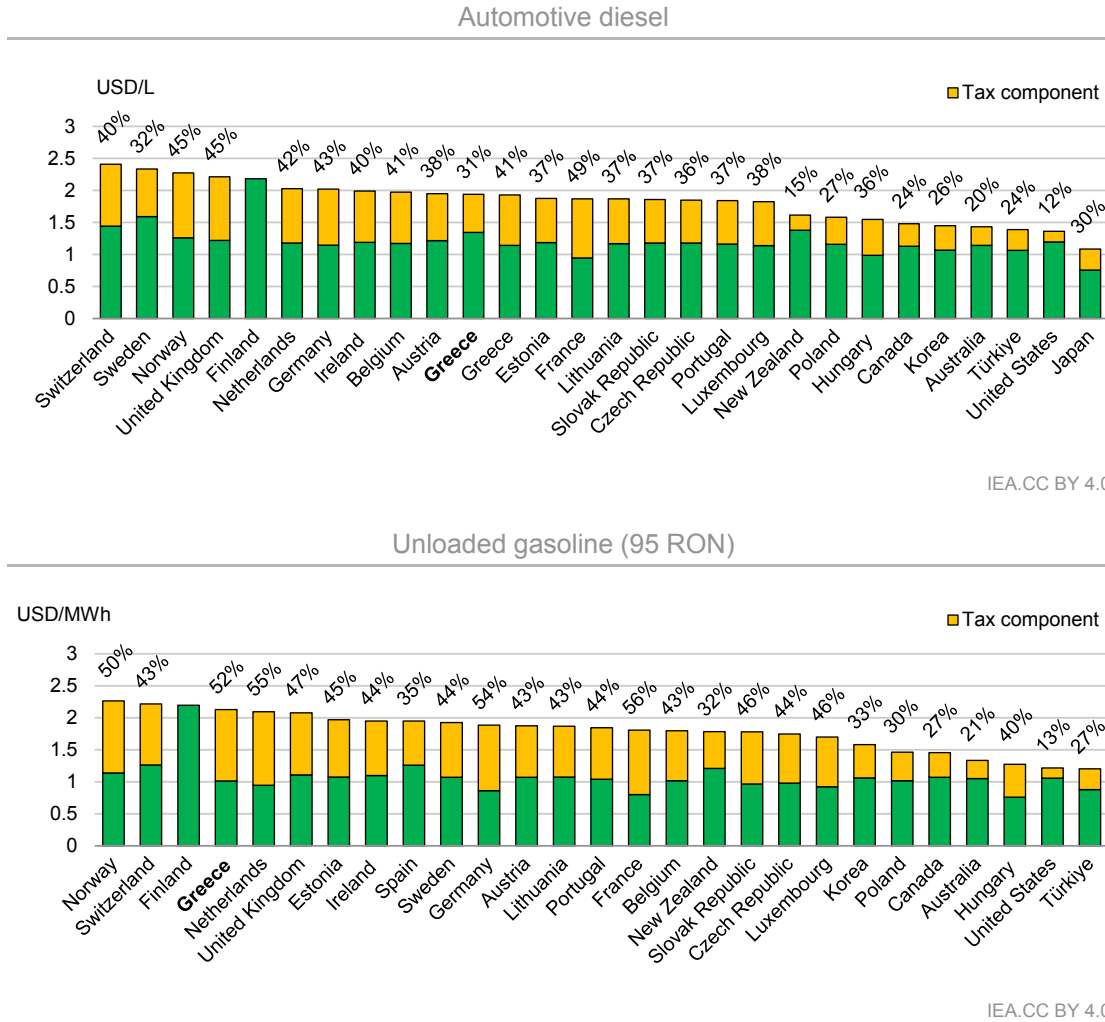
Greece's automotive diesel prices in the third quarter of 2022 were the 11th highest among IEA member countries, at 1.93 USD/litre, with a tax rate of 31%; higher than the IEA average price of 1.83 USD/litre but lower than IEA's tax rate of 33% (Figure 8.8). Greece's unleaded gasoline (RON 95) price was the fourth-highest among IEA member countries, at 2.13 USD/litre, with a tax rate of 52%. The average price for unleaded gasoline among IEA member countries was 1.79 USD/litre, with an average tax rate of 39% (Figure 8.8).

Figure 8.8 Price comparison for transportation fuels in the IEA, 3Q 2022



In the third quarter of 2022, Greece's unleaded gasoline prices were among the highest of IEA member countries, while diesel prices were closer to the IEA median.

Notes: Tax component data are unavailable for Finland for 3Q 2022; automotive diesel data are unavailable for Denmark, Italy and Mexico for 3Q 2022; premium unleaded gasoline (95 RON) data are unavailable for Denmark, Italy, Japan and Mexico for 3Q 2022. Source: IEA (2022b).

Oil policy

Greece's energy policy is focused on maintaining security of oil supply while reducing demand for oil in line with GHG emissions reduction targets and protecting consumers from high energy prices. The NECP foresees oil demand declining over the long term as

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a result of government policies to promote renewables, energy efficiency and a modal shift away from private cars. From 2020 to 2030, the government expects oil demand to decrease by almost 100% for electricity generation, 66% for residential buildings, 39% for industry, 30% for service sector buildings but only 4% for the transport sector (with some decline in road transport oil demand offset by increasing oil demand from marine shipping and aviation).

The key measures to reduce oil demand focus on road transportation, by far the largest source of oil demand (89% in 2020). The main policy to reduce oil demand in road transport is a biofuel blending mandate, which requires shares of biofuels in the annual fuel sales of all producers and distributors of road transportation fuels. The required shares are set annually by government decision. In 2017, the blending share of biodiesel in diesel (by volume) increased from 5.75% to 7% and remained at this level through 2022. In 2019, the mandate was extended to require a 1% share of bioethanol or bioethers in gasoline (by energy content), with the share increasing to 3.3% in 2020 and no change until 2022. There is also an overall requirement that 0.2% of blended biofuels meet the EU standard for advanced biofuels. The government is assessing a potential increase in the required shares under the biofuel mandate.

Greece also aims to reduce oil demand in road transport by supporting EVs. The NECP sets targets for EVs to account for at least 8.7% of new passenger car registrations by 2024 and 30% by 2030 (compared to 6.5% in 2021). Greece has a range of support measures to increase EV adoption, including direct subsidies, reduced taxes and registration fees, and support for EV charging infrastructure (see Chapter 3). However, the NECP shows that the government expects biofuels to remain the key option for reducing road transport oil demand through 2030.

The government also aims to reduce road transport oil demand by supporting a modal shift away from private cars. Since 2021, all regional authorities and certain municipalities are obliged to prepare sustainable urban mobility plans (SUMPs). SUMPs promote the use of public transport, walking and cycling, and mobility management. The government can financially support the measures proposed in the SUMPs as part of the Public Investment Program or other financial instruments. There are also efforts to reduce oil demand through the expansion and increased electrification of the Greek rail system for passengers and freight.

Greece is looking at options to reduce oil demand from marine shipping, which plays a major role in its economy and is a significant source of oil demand (9% in 2020). In 2018, the port of Killini demonstrated a project to allow docked ships to be connected to the electricity grid to allow their engines to be turned off while docked. In February 2022, the government held meetings to discuss the legal and regulatory changes needed to allow shore powering of docked ships. Greece participates in the European programme “Poseidon Med II”, which aims to introduce LNG into the shipping industry as the main fuel, as well as in the development of the infrastructure network for refuelling. The gas TSO has plans to invest in infrastructure that would support LNG power shipping.

The government also aims to reduce oil-fired heating in the buildings sector. Oil was the second-largest source of energy for buildings in 2020, covering 24% of total building energy demand and 31% of residential building energy demand, the fourth-highest share among IEA countries. In the Climate Law of 2022, the government has set regulations to limit the installation and use of oil-heating boilers. From 2025, the installation of oil boilers

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will be banned, and from 2030, oil for heating will have to contain at least 30% renewable liquid fuels (by volume). Several of the support schemes for building renovations provide subsidies or other support for transitioning away from oil-fired heating (see Chapter 3). There are no specific policies aiming to reduce oil demand from industry.

Greece is also aiming to largely eliminate oil-fired electricity generation, which takes place mainly on the Greek islands. Greece has a goal to interconnect all populated islands to the mainland grid by 2030. The electricity TSO Development Plan commits significant resources to interconnecting the islands. Greece's recovery and resilience plan also includes EUR 200 million to support the interconnection of the islands (see Chapter 6). There are also plans to reduce oil demand from oil-fired generation by deploying renewable energy on the islands (see Chapter 3).

Following the Russian invasion of Ukraine, the European Union imposed sanctions banning seaborne imports of Russian crude oil (which started on 5 December 2022) and Russian oil product imports (which started on 5 February 2023). These bans ended Russian imports to Greece, as these imports were only delivered by ship. Greece's refineries have secured contracts to replace the imports from Russia with supplies from other countries. There are also efforts to increase domestic oil production.

Addressing the impacts of high oil prices

As of the fall of 2021, global energy prices began to increase rapidly, especially in Europe. Price spikes and high volatility persisted into 2022, driven mainly by the impacts of the Russian invasion of Ukraine. Greece has taken numerous steps to limit the impact of high energy prices, especially for vulnerable consumers. These efforts include expanding existing measures targeting energy poverty and introducing broader measures to reduce energy prices for most consumers. From September 2021 to November 2022, Greece dedicated EUR 9 billion to energy subsidies and other measures to help consumers pay their energy bills. Most of this support was delivered through the Energy Transition Fund, which was established in 2021 to fund a variety of subsidies for electricity, natural gas, heating oil and transportation fuels.

The heating oil allowance (established in 2019) provides grants to vulnerable consumers to reduce the cost of oil-based heating. In 2021, the requirement for the heating allowance was relaxed to increase the number of consumers covered, and additional funding was provided from the Energy Transition Fund. The allowance is a grant of EUR 100-750 per year for households with an annual income between EUR 14 000 and EUR 29 000 and property value between EUR 180 000 and EUR 250 000. There are other requirements intended to focus the grants on vulnerable consumers, and a complex formula is used to calculate the level of the subsidy based on income, type of household and estimated heating demand. In 2021, around 1 million households received a heating allowance (up from 700 000 in 2020) for a cost of EUR 168 million (up from EUR 84 million in 2020) (Athens News, 2021).

In April 2022, the government launched an online platform providing direct payments to consumers to offset the high cost of road transportation fuels. The transport fuel subsidy is 0.15-0.2 EUR/litre for up to 60 litres of fuel per month and is available to consumers with an annual income below EUR 30 000. EUR 130 million were budgeted for fuel subsidies in April, May and June 2022 and EUR 200 million for fuel subsidies in July, August and September 2022.

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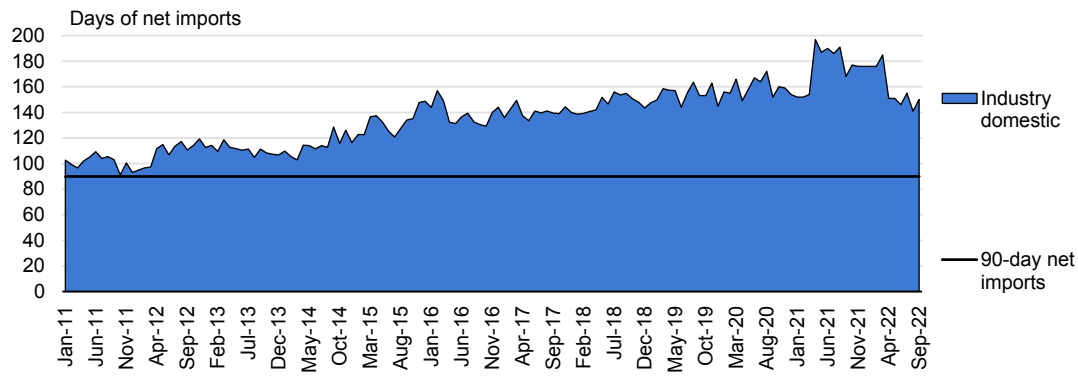
Oil emergency response policy

Greece maintains stocks of crude oil and oil products to ensure adequate supplies during emergency situations and to meet IEA and EU stockholding obligations. IEA member countries are obliged to hold emergency oil stocks (crude or oil products) equivalent to at least 90 days of annual net oil imports or 61 days of consumption, whichever is higher. Greece has consistently held stocks above the IEA 90-day obligation, with 141 days of stocks at the end of August 2022 (Figure 8.9).

In Greece, oil stocks are held by private industry at storage sites across the country. The legal framework permits keeping up to 30% of stocks in other EU member states, transposing fully the provisions of the respective European Directive. In 2021 and 2022, Greek oil companies signed ticket agreements with oil companies located in Malta and Cyprus to hold emergency stocks. Legislation allows for the creation of a central stockholding agency that could purchase and manage government-held oil stocks. However, no such agency exists, and the government has not indicated any interest in creating one. Under Greek law (Law 4123/2013), all companies that import oil to Greece and large end users importing petroleum oil products for own consumption are required to hold oil stocks equivalent to 90 days of their net imports during the previous calendar year.

Figure 8.9 Emergency oil stocks by type in Greece, January 2011 to September 2022



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Source: IEA (2022b).

Refineries are required to maintain at least one-third of their obligation in the form of final oil products. For the remaining two-thirds of their obligation, refineries can keep stocks of crude oil, refinery feedstocks and additives/oxygenates, or final oil products. All other companies covered by the stockholding obligation must hold stocks of each oil product they imported during the previous calendar year. In addition to the obligation to hold emergency stocks, each oil trade licence holder, with the exception of bitumen marketing licences, is required to maintain commercial stocks equivalent to at least five days of sales realised by each holder in the domestic market during the previous year, for each category of products accordingly with the licence category.

The MoEE has the authority to ensure compliance with emergency and commercial oil stockholding requirements and can issue sanctions for non-compliance. Companies required to maintain emergency stocks must submit a monthly report to the MoEE's Directorate of Hydrocarbons showing the level of emergency stocks held within their

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facilities and those owned by them but held in facilities of other economic operators or other countries' stockholding entities. In practice, emergency stocks are commingled with operational and/or commercial stocks, but emergency stocks must be held in storage tanks that have been certified by the Directorate of Hydrocarbons.

The National Emergency Plan (NEP) is the key document defining how Greece responds to an oil supply disruption. It details the process for identifying and officially declaring a supply disruption. It notes the competent entities, processes and measures to handle a supply disruption depending on how much supply is lacking and the scope of the disruption (international, regional, domestic, etc.). It also specifies sanctions that may be taken for non-compliance by parties with responsibilities to act during a supply crisis. The NEP comes into force and is terminated based on the decision of the MoEE.

To support rapid and effective decision making during an oil crisis, the NEP is complemented by an Operational Handbook, published in December 2021. The handbook is intended to provide a clear overview of the entire emergency response process. It notes the key actors and their roles and defines five escalating levels of local supply emergencies based on the amount of supply lacking in the market. It advises on the appropriate measures to be taken at each level; these include the measures defined in the NEP, along with new measures such as teleworking, and how these measures can be effectively combined. It also outlines ten possible oil supply disruption scenarios and details necessary processes and possible measures for each scenario.

Greece aims to manage oil supply disruptions through demand restraint measures, measures affecting the level of oil supply and other measures (e.g. financial). The NEP and Operational Handbook define these measures that allow increasing levels of market interventions to minimise the impacts of a disruption on Greece's economy, security and safety. The country will start with voluntary measures to reduce demand or increase supply, which can be escalated to mandatory measures. Voluntary demand restraint measures include: use of public transport and motorbikes or bicycles instead of private vehicles, carpooling and/or using taxis, saving energy in households and businesses, and reducing traffic and ecological driving. Compulsory demand restraint measures include restrictions on the circulation of means of transport, restrictions on energy consumption, obligatory use of alternative fuels, restrictions on the operation of industrial facilities, and limitations on oil product supply to consumers (ration cards). If these measures are insufficient to address the disruption, the government can order releases of emergency oil stocks and/or obligatory production of specific quantities of particular oil products by the refineries to ensure adequate supply.

The MoEE has overall responsibility for setting oil security policy. The Committee for the Management of Severe Supply Disruption of Crude Oil and Petroleum Products (CMSD) plays a key role in defining and implementing oil security policy and managing the response to an oil supply disruption. The CMSD is chaired by the Secretary General of the MoEE and includes the Chair of the RAE; directors of the MoEE; and representatives from relevant ministries, the armed forces and the oil industry.

The CMSD proposes emergency measures for consideration by the MoEE, advises the MoEE on issues related to emergency stocks, co-operates with the European Union and the IEA on issues related to oil stock releases, and checks on licence holders to ensure they can effectively support emergency response measures. In the aftermath of a crisis, the CMSD supervises the lifting of any implemented emergency measures.

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If a supply disruption requires the implementation of measures involving government interventions, the Coordination Committee for the Implementation of Emergency Measures is established. It plays a key role in the timely and effective implementation of emergency measures by various government bodies.

Assessment

Greece's demand for oil has been declining, but oil still plays an essential role in its energy system. In 2021, oil covered almost all transport energy demand (95%) and significant shares of energy demand in industry (36%), buildings (21%) and electricity generation (8.5%). Greece has only limited domestic oil production and is reliant on oil imports to cover around 99% of its oil demand. Greece's energy policy is focused on maintaining security of oil supply while reducing demand for oil in line with GHG emissions reduction targets and protecting consumers from high energy prices. The government has introduced a variety of measures to reduce oil demand.

Key measures to reduce oil demand from transport include a biofuel blending mandate and a variety of support mechanisms for electric vehicles and EV charging infrastructure. Greece has a relatively high use of oil-fired heating but is taking steps to transition to other heating sources. The 2022 Climate Law bans the installation of oil boilers starting in 2025 and demands that heating oil contain at least 30% renewable liquid fuels by 2030. There is support available for replacing oil boilers as part of government-funded renovation programmes. There is also a major effort to end the use of oil-fired electricity generation on Greek islands through interconnection to the mainland and the deployment of renewables.

Based on existing and planned measures, the NECP foresees oil demand declining over the long term as a result of government policies to promote renewables, energy efficiency and a modal shift away from private cars. From 2020 to 2030, the government expects oil demand to decrease by almost 100% for electricity generation, 66% for residential buildings, 39% for industry, 30% for service sector buildings but only 4% for the transport sector (with some decline in road transport oil demand offset by increasing oil demand from marine shipping and aviation).

The government needs to make additional efforts to ensure oil demand can be rapidly reduced in line with increasing EU climate and energy security ambitions. There should be an increased focus on boosting support for electrification and the use of sustainable biofuels. In addition, greater efforts are needed to tackle the expected increase in air and maritime transport.

The government has indicated an interest in raising the shares required by the biofuel blending mandate. The IEA recommends regularly increasing these shares, with a focus on increasing the share of advanced sustainable biofuels to ensure sustained reductions in transport oil demand. The government should also consider expanding the blending requirement to aviation and shipping.

The main producers of biofuels in Greece are refineries, which have a significant spare biofuel production capacity, with only 15% of their capacity in operation in 2021. Greece should use its full biofuels production potential to help reduce oil demand. The government

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should work with industry and consider providing subsidies as needed to ensure Greece can produce the needed volumes of sustainable advanced biofuels.

The NECP includes a priority for "replacement of polluting passenger vehicles and freight vehicles". Greece's passenger and freight fleets are significantly older than the EU average, leading to increased oil demand and higher GHG emissions. The old age of the fleet also limits the ability of biofuels to reduce oil demand. With an average vehicle age of 16.6 years, many vehicles cannot run on gasoline with more than 5% ethanol.

More efforts are needed to support Greek consumers in purchasing newer vehicles with a clear focus on efficiency and electrification. The renovation of the car fleet should be promoted through a cash-for-clunkers programme that gives consumers subsidies to purchase new or used high-efficiency vehicles if they scrap an old vehicle. In addition, the government should support establishing low-carbon emissions zones in cities to exclude very polluting cars while at the same time promoting car sharing and sustainable public transport, walking and cycling.

There are numerous reductions and exemptions for the excise duty on oil products, depending on the sector/end use. As an EU member state, Greece has committed to eliminate fossil fuel subsidies. However, the OECD estimates that in 2020, Greece provided over EUR 1.9 billion in fossil fuel subsidies. Some of the largest subsidies relate to oil use, including EUR 0.19 billion in reduced excise taxes on diesel used for heating, EUR 0.17 billion for heating allowances to households and EUR 0.4 billion in subsidies to oil-fired electricity generation in non-interconnected islands. From 2015 to 2020, government support for fossil fuels decreased by 14% (reductions in direct transfers supporting oil-fired electricity generation in non-interconnected islands and lower spending on heating allowances); however, spending on heating allowances increased substantially in 2021 and 2022. In 2020, fossil fuel subsidies were equivalent to more than one-quarter of energy tax revenue, among the highest rates in the OECD (OECD, 2022).

The government should review oil taxation policies to reduce fossil fuel subsidies and end favourable taxation of diesel so that price signals steer consumers towards less polluting and more efficient options. Taxation convergence for diesel and gasoline is already a reality in many IEA countries, such as Belgium, Canada, France, Switzerland, the United Kingdom and the United States. Saved expenditures from eliminating fossil fuel subsidies can be directed to existing or new programmes to help consumers adopt more efficient options.

Since the IEA's last Energy Policy Review in 2017, Greece has increased competition at the wholesale and retail levels. However, the oil markets still have a relatively high level of market concentration and limited competition. In 2021, there were 56 companies active in the Greek wholesale oil market, a slight increase compared to 53 in 2016. However, just nine companies dominate the wholesale market supply, with a combined market share of 83% in 2020, while the largest supplier had a market share of 29%. There is also notable market concentration at the retail level, with the two largest companies, HELPE and Motor Oil, together owning over 40% of operational retail services stations. The government should continue working to increase oil market competition and reduce the barriers to the entrance of new companies. Price transparency and consumer awareness could be increased by updating the website for fuel prices to make it more user-friendly.

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Recommendations

The government of Greece should:

- Increase support for electrification and advanced biofuel fuels, and make greater efforts to tackle the expected increase in air and maritime transport.
- Incentivise substitution of the old car fleet, ensuring that old cars are taken out of circulation and replaced with more efficient vehicles and electric vehicles.
- Review oil taxation policies to reduce fossil fuel subsidies and end the favourable taxation of diesel so that price signals steer consumers towards less polluting and more efficient options.
- Further promote competition in the retail oil fuel markets by increasing the number of new companies and raise awareness of the existence of the price monitoring mechanism through informative campaigns.

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ANNEX A: Review team and supporting stakeholders

Review criteria

The Shared Goals, adopted by the IEA Ministers at their 4 June 1993 meeting in Paris, provide the evaluation criteria for the in-depth reviews. The IEA Shared Goals are available on line.

Review team and preparation of the report

The IEA's in-depth review visit of Greece took place on 12-18 July 2022. The review team met with government officials, energy suppliers, market participants, interest groups, consumer associations, research institutions and other stakeholders. The report was drafted based on information obtained in these meetings, the review team's assessment of Greece's energy policy, the government's response to the IEA energy policy questionnaire and subsequent research by the IEA. The members of the team were

IEA member countries

Lars Maindert, Netherlands (team leader)

József Lezsák, Hungary

Naoko Doi, Japan

Michele de Nigris, Italy

Markela Stamati, European Commission

Nathan Reich, United States

José Luis Cabo Sánchez, Spain

International Energy Agency

Aad van Bohemen

Kiyomi Hyoe

Peter Journeay-Kaler

The team is grateful for the co-operation and assistance of the many people who supported the review. Thanks to their hospitality, openness and willingness to share information, the visit was highly informative, productive and enjoyable. The team expresses its gratitude to His Excellency Mr Konstantinos Skrekas, Minister of Environment and Energy, as well as the government officials, including Mrs Alexandra Sdoukou, Secretary General for Energy and Mineral Resources; Petros Varelidis, Secretary General for Natural Environment and Water; and Ioannis Xifaras, Secretary General for Transport, whose comments helped frame all the discussions during the review. The team extends a special thanks to Stelios Alifantis, Vassiliki Sita, Georgios Choundri, Kaita Karamichalakou and Katerina Koumentakou for their tireless efforts in co-ordinating the review visit, prompt responses to the team's many requests and patience throughout the weeks leading up to, during and after the review.

The review was prepared under the guidance of Mr Aad van Bohemen, Head of the Energy Policy and Security Division, IEA. Mr Peter Journeay-Kaler managed the review and is the author of the report.

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Ms Kiyomi Hyoe co-ordinated the emergency response component of the review and contributed to the chapters on oil, natural gas and electricity. Mr Alessio Scanziani wrote the chapter on energy efficiency. Mr Alessio Scanziani, Mr Anders Caratozzolo, Ms Clémence Lizé, Ms Su Min Park and Han Young Chang prepared and drafted the sections relating to energy data contained in each chapter. Helpful comments, chapter reviews and updates were provided by the following IEA staff: Orestis Karampinis, Simon Bennet, Insa Handschuch, Britta Labuhn, Chiara D'Adamo, Heymi Bahar, Jacques Warichet, Enrique Gutierrez Tavarez, Rena Kuwahata, Gergely Molnar, Kristine Petrosyan, Yuya Akizuki and Toril Bosoni.

Special thanks to the IEA Secretariat with regard to the data, publication and editing. Astrid Dumond and Isabelle Nonain-Semelin managed the editing, layout and publication. Tanya Dyhin and Charner Ramsey prepared the maps. Roberta Quadrelli, Steve Gervais and Zakia Adam provided support on statistics. Jad Mouwad, Jethro Mullen and Gregory Viscusi supported the press launch. Jennifer Allian was the editor.

Meetings held with the following organisations

Centre for Renewable Energy Sources (CRES)
Centre of Research and Technology (CERTH)
Dimósia Epicheírisi Aeríou (DEPA)
ELPEDISON
Executive Authority of the Partnership Agreement
Greek Association of Res Electricity Producers (HELLASRES)
Greenpeace Greece
Hellenic Association of Photovoltaic Energy Producers (SPEF)
Hellenic Association of Small Hydroelectric Plants (ESMYE)
Hellenic Electricity Distribution Network Operator S.A. (HEDNO)
Hellenic Energy Exchange (HEnEX S.A.)
Hellenic Hydrocarbon Resources Management (HHRM)
Hellenic Petroleum R.S.S.O.P.P. S.A. (HELPE)
Hellenic Wind Energy Association (HWEA – ELETAEN)
HERON Energy S.A.
Independent Power Transmission Operator (IPTO)
Innovation Hub
Institute for Energy of Southeastern Europe (IENE)
Ministry of Development and Investments – General Secretariat for Research and Innovation (GSRI)
Ministry of Environment and Energy
Ministry of Infrastructure and Transport
Motor Oil Hellas
National Natural Gas System Operator S.A. (DESFA)
National Technical University of Athens (NTUA)
Network of Sustainable Greek Islands (DAFNI Network)
Operator of Renewable Energy Sources and Guarantees of Origin (DAPEEP)
Public Power Corporation S.A. (PPC)

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Rythmistiki Archi Energeias (RAE)

The Green Tank

Trans Adriatic Pipeline AG (TAP)

World Wildlife Fund Greece (WWF)

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ANNEX B: Key statistical data and notes

Unit: PJ

SUPPLY		1973	1990	2000	2010	2019	2020	2021
TOTAL PRODUCTION		**97.7**	**385.1**	**420.5**	**397.5**	**252.2**	**190.7**	**198.8**
Coal		70.9	298.0	344.2	306.3	129.3	68.3	60.3
Peat		-	-	-	-	-	-	-
Oil		-	35.1	10.7	4.4	6.9	3.7	2.4
Natural gas		-	5.8	1.8	0.3	0.4	0.3	0.2
Biofuels and waste[1]		18.8	37.4	42.3	38.5	46.7	44.4	45.2
Nuclear		-	-	-	-	-	-	-
Hydro		8.0	6.4	13.3	26.9	14.4	12.0	21.3
Wind		-	0.0	1.6	9.8	26.2	33.5	37.7
Geothermal		-	0.1	0.1	0.7	0.4	0.2	0.2
Solar/other		-	2.4	6.5	10.7	27.9	28.3	31.6
TOTAL NET IMPORTS[2]		**442.8**	**502.5**	**728.2**	**743.2**	**651.4**	**663.3**	**609.6**
Coal	Exports	0.9	-	1.7	-	-	0.0	-
	Imports	19.7	38.5	33.9	16.8	8.5	7.8	6.9
	Net imports	18.8	38.5	32.2	16.8	8.5	7.8	6.9
Oil	Exports	204.4	312.1	171.0	401.6	776.3	797.3	885.3
	Imports	689.4	912.5	979.9	1114.2	1350.1	1296.2	1353.0
	Int'l marine and aviation bunker	-61.2	-139.0	-183.6	-142.0	-152.8	-83.0	-105.0
	Net imports	423.9	461.4	625.3	570.6	421.0	415.9	362.7
Natural gas	Exports	-	-	-	-	0.6	1.2	0.6
	Imports	-	-	70.7	135.3	186.6	209.0	227.3
	Net imports	-	-	70.7	135.3	186.1	207.8	226.8
Electricity	Exports	0.1	2.2	6.3	10.1	4.0	3.5	14.0
	Imports	0.3	4.8	6.2	30.7	39.8	35.4	27.3
	Net imports	0.2	2.6	-0.0	20.5	35.8	31.9	13.3
TOTAL STOCK CHANGES		**-46.1**	**10.1**	**-12.2**	**11.0**	**16.1**	**-34.9**	**37.2**
TOTAL SUPPLY (TES)[3]		**494.5**	**897.7**	**1136.5**	**1158.3**	**924.1**	**824.4**	**851.0**
Coal		88.1	337.7	378.4	329.2	133.8	76.7	71.6
Peat		-	-	-	-	-	-	-
Oil		379.4	505.4	623.0	580.0	446.7	386.1	396.4
Natural gas		-	5.8	71.4	135.4	188.0	206.3	228.1
Biofuels and waste[1]		18.8	37.4	42.3	45.0	50.9	49.3	50.7
Nuclear		-	-	-	-	-	-	-
Hydro		8.0	6.4	13.3	26.9	14.4	12.0	21.3
Wind		-	0.0	1.6	9.8	26.2	33.5	37.7
Geothermal		-	0.1	0.1	0.7	0.4	0.2	0.2
Solar/other		-	2.4	6.5	10.7	27.9	28.3	31.6
Electricity trade[4]		0.2	2.6	-0.0	20.5	35.8	31.9	13.3
Shares in TES (%)								
Coal		*17.8*	*37.6*	*33.3*	*28.4*	*14.5*	*9.3*	*8.4*
Peat		-	-	-	-	-	-	-
Oil		*76.7*	*56.3*	*54.8*	*50.1*	*48.3*	*46.8*	*46.6*
Natural gas		-	*0.6*	*6.3*	*11.7*	*20.3*	*25.0*	*26.8*
Biofuels and waste[1]		*3.8*	*4.2*	*3.7*	*3.9*	*5.5*	*6.0*	*6.0*
Nuclear		-	-	-	-	-	-	-
Hydro		*1.6*	*0.7*	*1.2*	*2.3*	*1.6*	*1.5*	*2.5*
Wind		-	-	*0.1*	*0.8*	*2.8*	*4.1*	*4.4*
Geothermal		-	*0.0*	*0.0*	*0.1*	*0.0*	*0.0*	*0.0*
Solar/other		-	*0.3*	*0.6*	*0.9*	*3.0*	*3.4*	*3.7*
Electricity trade[4]		-	*0.3*	-	*1.8*	*3.9*	*3.9*	*1.6*

0 is negligible, - is nil, .. is not available, x is not applicable. Please note: rounding may cause totals to differ from the sum of the elements.

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Unit: PJ

DEMAND							
FINAL CONSUMPTION	**1973**	**1990**	**2000**	**2010**	**2019**	**2020**	**2021**
TFC	**357.0**	**606.8**	**775.1**	**815.8**	**668.4**	**624.0**	**636.8**
Coal	21.8	51.0	36.7	12.6	8.3	7.0	7.7
Peat	-	-	-	-	-	-	-
Oil	270.7	409.4	519.7	510.0	365.5	326.4	330.0
Natural gas	-	4.0	15.8	47.5	55.5	61.7	62.0
Biofuels and waste[1]	18.8	37.4	39.6	41.7	44.5	43.6	45.4
Geothermal	-	0.1	0.1	0.7	0.4	0.2	0.2
Solar/other	-	2.4	6.5	10.1	12.0	12.3	12.7
Electricity	45.8	102.5	155.3	191.2	180.7	171.1	177.3
Heat	-	-	1.2	1.9	1.6	1.7	1.5
Shares in TFC (%)							
Coal	*6.1*	*8.4*	*4.7*	*1.5*	*1.2*	*1.1*	*1.2*
Peat	-	-	-	-	-	-	-
Oil	*75.8*	*67.5*	*67.1*	*62.5*	*54.7*	*52.3*	*51.8*
Natural gas	-	*0.7*	*2.0*	*5.8*	*8.3*	*9.9*	*9.7*
Biofuels and waste[1]	*5.3*	*6.2*	*5.1*	*5.1*	*6.7*	*7.0*	*7.1*
Geothermal	-	*0.0*	*0.0*	*0.1*	*0.1*	*0.0*	-
Solar/other	-	*0.4*	*0.8*	*1.2*	*1.8*	*2.0*	*2.0*
Electricity	*12.8*	*16.9*	*20.0*	*23.4*	*27.0*	*27.4*	*27.8*
Heat	-	-	*0.2*	*0.2*	*0.2*	*0.3*	*0.2*
TOTAL INDUSTRY[5]	**145.1**	**196.1**	**215.9**	**191.8**	**146.9**	**140.0**	**138.3**
Coal	19.2	49.6	35.7	12.5	8.1	6.8	7.5
Peat	-	-	-	-	-	-	-
Oil	99.4	90.9	106.4	87.6	56.7	47.5	47.4
Natural gas	-	4.0	15.3	30.5	31.9	36.5	34.0
Biofuels and waste[1]	-	8.0	9.8	10.3	5.8	6.5	5.5
Geothermal	-	-	-	-	0.0	0.0	0.0
Solar/other	-	-	0.0	0.1	0.1	0.1	0.1
Electricity	26.5	43.6	48.8	50.9	44.3	42.7	43.8
Heat	-	-	-	-	-	-	-
Shares in total industry (%)							
Coal	*13.2*	*25.3*	*16.5*	*6.5*	*5.5*	*4.9*	*5.4*
Peat	-	-	-	-	-	-	-
Oil	*68.5*	*46.3*	*49.3*	*45.7*	*38.6*	*33.9*	*34.3*
Natural gas	-	*2.1*	*7.1*	*15.9*	*21.7*	*26.0*	*24.6*
Biofuels and waste[1]	-	*4.1*	*4.5*	*5.4*	*4.0*	*4.6*	*3.9*
Geothermal	-	-	-	-	-	-	-
Solar/other	-	-	-	-	-	-	*0.1*
Electricity	*18.3*	*22.2*	*22.6*	*26.5*	*30.2*	*30.5*	*31.7*
Heat	-	-	-	-	-	-	-
TRANSPORT[3]	**86.6**	**211.0**	**267.9**	**313.2**	**253.1**	**215.3**	**231.5**
OTHER[6]	**125.3**	**199.8**	**291.3**	**310.8**	**268.4**	**268.7**	**267.0**
Coal	1.9	1.4	1.0	0.1	0.2	0.2	0.2
Peat	-	-	-	-	-	-	-
Oil	85.6	108.1	146.3	115.9	65.0	73.4	61.6
Natural gas	-	-	0.6	16.5	22.8	24.4	27.2
Biofuels and waste[1]	18.8	29.4	29.8	26.0	30.9	28.7	30.9
Geothermal	-	0.1	0.1	0.7	0.4	0.2	0.2
Solar/other	-	2.4	6.5	10.1	11.9	12.2	12.7
Electricity	19.1	58.5	105.8	139.7	135.7	127.8	132.8
Heat	-	-	1.2	1.9	1.6	1.7	1.5
Shares in other (%)							
Coal	*1.5*	*0.7*	*0.4*	-	*0.1*	*0.1*	*0.1*
Peat	-	-	-	-	-	-	-
Oil	*68.3*	*54.1*	*50.2*	*37.3*	*24.2*	*27.3*	*23.1*
Natural gas	-	-	*0.2*	*5.3*	*8.5*	*9.1*	*10.2*
Biofuels and waste[1]	*15.0*	*14.7*	*10.2*	*8.4*	*11.5*	*10.7*	*11.6*
Geothermal	-	*0.1*	*0.0*	*0.2*	*0.2*	*0.1*	*0.1*
Solar/other	-	*1.2*	*2.2*	*3.2*	*4.4*	*4.5*	*4.7*
Electricity	*15.2*	*29.3*	*36.3*	*44.9*	*50.6*	*47.6*	*49.7*
Heat	-	-	*0.4*	*0.6*	*0.6*	*0.6*	*0.6*

0 is negligible, - is nil, .. is not available, x is not applicable. Please note: rounding may cause totals to differ from the sum of the elements.

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Unit: PJ

DEMAND							
ENERGY TRANSFORMATION AND LOSSES	**1973**	**1990**	**2000**	**2010**	**2019**	**2020**	**2021**
ELECTRICITY GENERATION[7]							
Input (PJ)	139.4	372.3	501.6	509.7	372.4	319.4	351.1
Output (PJ)	53.4	125.2	192.4	206.6	174.9	173.4	196.8
Output (TWh)	14.8	34.8	53.4	57.4	48.6	48.2	54.7
Output shares (%)							
Coal	*35.5*	*72.4*	*64.2*	*53.7*	*25.0*	*13.7*	*9.7*
Peat	-	-	-	-	-	-	-
Oil	*49.5*	*22.3*	*16.6*	*10.6*	*11.5*	*9.8*	*8.5*
Natural gas	-	*0.3*	*11.1*	*17.1*	*29.8*	*39.9*	*41.1*
Biofuels and waste[1]	-	-	*0.3*	*0.6*	*1.4*	*1.0*	*1.0*
Nuclear	-	-	-	-	-	-	-
Hydro	*15.0*	*5.1*	*6.9*	*13.0*	*8.2*	*6.9*	*10.8*
Wind	-	-	*0.8*	*4.7*	*15.0*	*19.3*	*19.2*
Geothermal	-	-	-	-	-	-	-
Solar/other	-	-	-	*0.3*	*9.1*	*9.2*	*9.6*
TOTAL LOSSES	**137.4**	**302.5**	**372.8**	**359.6**	**254.2**	**205.6**	**215.8**
of which:							
Electricity and heat generation[8]	86.1	247.1	308.1	301.1	195.3	143.9	152.4
Other transformation	24.7	0.1	-16.4	-24.3	-31.4	-32.4	-34.8
Own use and transmission/distribution losses	26.6	55.3	81.1	82.8	90.3	94.1	98.2
Statistical differences	**0.0**	**-11.7**	**-11.3**	**-17.2**	**1.4**	**-5.3**	**-1.6**
INDICATORS	**1973**	**1990**	**2000**	**2010**	**2019**	**2020**	**2021**
GDP (billion 2015 USD)	121.11	158.29	201.42	239.74	203.72	185.34	200.79
Population (millions)	9.02	10.27	10.81	11.12	10.72	10.71	10.67
TES/GDP (MJ per 2015 USD)[9]	4.08	5.67	5.64	4.83	4.53	4.45	4.24
Energy production/TES	0.20	0.43	0.37	0.34	0.27	0.23	0.23
Per capita TES (GJ per capita)	54.81	87.44	105.17	104.15	86.19	76.97	79.76
Oil supply/GDP (MJ per 2015 USD)[9]	3.13	3.19	3.09	2.42	2.19	2.09	1.98
TFC/GDP (MJ per 2015 USD)[9]	2.95	3.84	3.85	3.40	3.28	3.37	3.17
Per capita TFC (GJ per capita)	39.57	59.11	71.72	73.36	62.34	58.26	59.69
CO_2 emissions from fuel combustion ($MtCO_2$)[10]	33.7	69.9	87.9	83.4	56.6	48.0	49.7
CO_2 emissions from bunkers ($MtCO_2$)[10]	2.8	8.1	11.5	8.7	8.1	5.2	5.8
GROWTH RATES (% per year)	**73-90**	**90-00**	**00-10**	**10-18**	**18-19**	**19-20**	**20-21**
TES	3.6	2.4	0.2	-2.6	-1.6	-10.8	3.2
Coal	8.2	1.1	-1.4	-6.6	-30.0	-42.7	-6.6
Peat	-	-	-	-	-	-	-
Oil	1.7	2.1	-0.7	-3.6	3.0	-13.6	2.7
Natural gas	-	28.6	6.6	3.1	9.0	9.8	10.6
Biofuels and waste[1]	4.1	1.2	0.6	1.4	1.4	-3.1	2.9
Nuclear	-	-	-	-	-	-	-
Hydro	-1.3	7.6	7.3	-3.2	-30.4	-16.4	76.6
Wind	-	71.9	19.7	11.1	15.3	28.1	12.6
Geothermal	-	-4.7	25.9	-7.1	16.4	-45.6	-23.0
Solar/other	-	10.7	5.0	11.4	10.5	1.3	11.8
TFC	3.2	2.5	0.5	-2.6	1.5	-6.6	2.0
Electricity consumption	4.9	4.2	2.1	-0.9	1.5	-5.3	3.6
Energy production	8.4	0.9	-0.6	-3.4	-16.5	-24.4	4.2
Net oil imports	0.5	3.1	-0.9	-3.7	-0.2	-1.2	-12.8
GDP	1.6	2.4	1.8	-2.2	1.8	-9.0	8.3
TES/GDP	2.0	-0.1	-1.5	-0.4	-3.4	-1.9	-4.7
TFC/GDP	1.6	0.0	-1.2	-0.4	-0.3	2.6	-5.8

0 is negligible, - is nil, .. is not available, x is not applicable. Please note: rounding may cause totals to differ from the sum of the elements.

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Footnotes to key statistical data

[1] Biofuels and waste comprise solid biofuels, liquid biofuels, biogases, and industrial waste. Data are often based on partial surveys and may not be comparable between countries.

[2] In addition to coal, oil, natural gas and electricity, total net imports also include biofuels.

[3] Excludes international marine bunkers and international aviation bunkers.

[4] Total supply of electricity represents net trade. A negative number in the share of TES indicates that exports are greater than imports.

[5] Industry includes non-energy use.

[6] Other includes residential, commercial and public services, agriculture/forestry, fishing and other non-specified.

[7] Inputs to electricity generation include inputs to electricity and CHP plants. Output refers only to electricity generation.

[8] Losses arising in the production of electricity and heat at main activity producer utilities and autoproducers. For non-fossil-fuel electricity generation, theoretical losses are shown based on plant efficiencies of approximately 100% for hydro, wind and solar photovoltaic.

[9] MJ per thousand US dollars at 2015 prices and exchange rates.

[10] " CO_2 emissions from fuel combustion" have been estimated using the IPCC Tier I Sectoral Approach methodology from the 2006 IPCC Guidelines. Emissions from international marine and aviation bunkers are not included in national totals.

Statistical notes for data used in the report

- Unless otherwise noted all GDP data are in USD 2015 prices and PPPs (Purchase Power Parity).
- *Total Energy Supply (TES)* comprises production + imports – exports – international marine and aviation bunkers ± stock changes. This equals the total supply of energy that is consumed domestically, either in transformation (e.g., electricity generation and refining) or in final use.
- *Total Final Consumption (TFC)* is the final consumption of energy (electricity, heat and fuels, such as natural gas and oil products) by end users, not including the transformation sector (e.g., power generation and refining).
- *Total final energy consumption (TFEC)* excludes non-energy use which is counted in total final consumption (TFC). TFEC provides a more accurate assessment of the share of energy demand covered by renewable energy and is better aligned with the EU's gross final energy consumption metric, which is used to set EU member state renewable energy targets.
- The shares of renewables in total final energy consumption, electricity generation, heating and cooling and transport differ if computed with IEA or Eurostat methodologies. Eurostat methodology includes multiplying factors and normalisation procedures.
- *Bioenergy* refers to solid and liquid biofuels, renewable waste and biogas and excludes non-renewable waste.
- *Buildings* includes the energy use of the residential sector (residential buildings) and commercial and public service sectors (service sector buildings).
- *Transport* excludes international aviation and navigation.
- *Industry* includes both energy and non-energy use of the industry sector, agriculture, forestry and fishing.
- *Non-energy use* refers to fuels used as raw materials, and not used as fuel or transformed into another fuel. This comprises typically raw materials used in the chemical and petrochemical sector.
- "IEA average" is the equivalent of a weighted average of the IEA member countries, excluding Lithuania.

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ANNEX C: Glossary and list of abbreviations

In this report, abbreviations and acronyms are substituted for a number of terms used within the International Energy Agency. While these terms generally have been written out on first mention, this glossary provides a quick and central reference for the abbreviations used.

Acronyms and abbreviations

AC	alternating current
CCGT	combined-cycle gas turbine
CCUS	carbon capture, utilisation and storage
CEE	energy-saving certificate (France) *certificat d'économies d'énergie*
CMSD	Committee for the Management of Severe Supply Disruption of Crude Oil and Petroleum Products
DC	direct current
DESFA	Hellenic Gas Transmission System Operator S.A.
DSO	distribution system operator
DSR	demand side response
EED	Energy Efficiency Directive
EEO	Energy Efficiency Obligation
EET	energy efficiency title
EPC	energy performance certificate
ESD	Effort Sharing Decision
ESR	Effort Sharing Regulation
ETMEAR	Special Duty of Greenhouse Gas Emissions Reduction
ETS	Emissions Trading System
EU	European Union
EUR	euro
EV	electric vehicle
FEC	final energy consumption
FIP	feed-in premium
FIT	feed-in tariff
GDP	gross domestic product
GHG	greenhouse gas
GSRI	General Secretariat for Research and Innovation
HEDNO	Hellenic Electricity Distribution Network Operator S.A.
HELPE	Hellenic Petroleum
HEnEX	Hellenic Energy Exchange
HHI	Herfindahl-Hirschman Index
HHRM	Hellenic Hydrocarbons Resources Management S.A.

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IGB	Interconnector Greece-Bulgaria
IPCEI	Important Project of Common European Interest
IPTO	Independent Power Transmission Operator S.A.
LNG	liquefied natural gas
LPG	liquefied petroleum gas
LULUCF	land use, land-use change and forestry
MoEE	Ministry of Environment and Energy
NECP	National Energy and Climate Plan
NEP	National Emergency Plan
NNGTS	National Natural Gas Transmission System
OECD	Organisation for Economic Co-operation and Development
PEC	primary energy consumption
PPC	Public Power Corporation S.A.
PSAPE	Information System for the Licensing of Renewable Energy Sources Projects
PV	photovoltaics
R&D	research and development
RAE	Regulatory Authority for Energy
RD&D	research, development and demonstration
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SME	small and medium-sized enterprise
SUMP	sustainable urban mobility plan
TAP	Trans-Adriatic Pipeline
TCP	technology collaboration programme
TES	total energy supply
TFC	total final consumption
TFEC	total final energy consumption
TSO	transmission system operator
UNFCCC	United Nations Framework Convention on Climate Change
USD	United States dollar
VAT	value-added tax

Units of measure

bcm	billion cubic metres
b/d	barrels per day
CO_2-eq	carbon dioxide-equivalent
g CO_2/km	gramme of carbon dioxide per kilometre
GJ	gigajoule
GW	gigawatt

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GWh	gigawatt hour
kb/d	thousand barrels per day
kg CO_2-eq	kilogramme carbon dioxide equivalent
kt CO_2	kilotonne carbon dioxide equivalent
ktoe	thousand tonnes of oil equivalent
kV	kilovolt
kWh	kilowatt hour
L	litre
mcm	million cubic metres
MJ	megajoule
Mt	million tonnes
Mt CO_2-eq	million tonnes of carbon dioxide equivalent
Mtoe	million tonnes of oil equivalent
MW	megawatt
MWh	megawatt hour
pkm	passenger-kilometre
tkm	tonne-kilometre
TWh	terawatt hour

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Unless otherwise indicated, all material presented in figures and tables is derived from IEA data and analysis.

We wish to acknowledge the traditional custodians of the land of the ACT Region where the in-depth review took place, the Ngunnawal people, and pay respect to their Elders, both past and present.

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Energy Policy Review

The International Energy Agency (IEA) regularly conducts in-depth peer reviews of the energy policies of its member countries. This process supports energy policy development and encourages the exchange of international best practices and experiences to help drive secure and affordable clean energy transitions.

Greece aims to reduce total greenhouse gas emissions by 55% by 2030 and reach net zero emissions by 2050. It has made notable progress towards meeting these targets. This includes significantly reducing its reliance on lignite and setting a binding target to end lignite-fired power generation by 2028 while working to ensure a just transition in its lignite mining regions and reducing energy poverty. Greece has also made strong progress on renewable energy, which covered 20% of its total final energy consumption in 2021.

Following Russia's invasion of Ukraine, Greece is reducing its reliance on Russian energy imports and ensuring secure access to energy by diversifying its supply and increasing domestic energy production.

Despite these notable successes, significant challenges remain. Fossil fuels still account for most of Greece's energy use and stronger efforts are needed on energy efficiency.

In this report, the IEA provides a range of energy policy recommendations to help Greece smoothly manage its transition to a secure, efficient and flexible carbon neutral energy system.