ENERGY POLICIES OF IEA COUNTRIES

Greece

2017 Review

International Energy Agency
Secure
Sustainable
Together

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INTERNATIONAL ENERGY AGENCY

The International Energy Agency (IEA), an autonomous agency, was established in November 1974. Its primary mandate was – and is – two-fold: to promote energy security amongst its member countries through collective response to physical disruptions in oil supply, and provide authoritative research and analysis on ways to ensure reliable, affordable and clean energy for its 29 member countries and beyond. The IEA carries out a comprehensive programme of energy co-operation among its member countries, each of which is obliged to hold oil stocks equivalent to 90 days of its net imports. The Agency's aims include the following objectives:

- Secure member countries' access to reliable and ample supplies of all forms of energy; in particular, through maintaining effective emergency response capabilities in case of oil supply disruptions.
- Promote sustainable energy policies that spur economic growth and environmental protection in a global context – particularly in terms of reducing greenhouse-gas emissions that contribute to climate change.
- Improve transparency of international markets through collection and analysis of energy data.
- Support global collaboration on energy technology to secure future energy supplies and mitigate their environmental impact, including through improved energy efficiency and development and deployment of low-carbon technologies.
- Find solutions to global energy challenges through engagement and dialogue with non-member countries, industry, international organisations and other stakeholders.

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Foreword

The International Energy Agency (IEA) has been conducting in-depth energy policy reviews of its member countries since 1976. As a core activity, the process of review by peers not only supports member countries' energy policy development and mutual learning, but also encourages exchange of international best practice and experience. In short, by seeing what has worked – or not – in the "real world", these reviews help to identify policies that achieve objectives and bring results.

In 2016, the IEA decided to modernise the reviews by shifting their focus to key energy security challenges in fast changing global energy markets, and to the transition to a clean energy system.

Greece has made significant efforts to advance energy sector reforms in a challenging environment of declining consumption and constrained finances. The government should be commended for progress made since the IEA's last review of the country's energy policies, but even greater effort will be required if Greece is to achieve its longer-term energy goals. The creation of competitive and price-responsive energy markets will be critical to ensuring long-term economic prospects while putting the country solidly on a path to a low- carbon economy.

This report focuses on two areas of special interest to the Greek government: promotion of renewable energy and energy efficiency.

Greece has prioritised development of its abundant renewable energy resources and as a result of a supportive policy environment, renewable sources today play a key role in the electricity sector. Building on this success, it is important for Greece to explore its renewable resources beyond solar and wind and to advance their usage in the non-electricity sectors. In this report, we look at the ongoing reforms to the support schemes for renewable energy and additional initiatives that Greece could put in place to further accelerate the shift towards renewable energy sources, including on the Greek islands, without compromising electricity security.

Another area in which Greece has targeted its policy efforts is energy efficiency. Although a number of new initiatives have been launched recently, there is still substantial room to improve efficiency, including in the building sector. Measures to enhance public awareness about the benefits of energy efficiency and making funding more accessible would support these efforts.

Embedding renewable energy and energy efficiency ambitions in a larger policy approach for emissions reductions, taking into account key parameters such as energy security and achieving lower costs across the energy sector, is a key objective of the government. It is the aim of this report to provide recommendations that support the Greek government's efforts to diversify energy sources and reduce the carbon intensity of the economy while implementing comprehensive energy market reforms to make the sector more competitive and clean.

It is my hope that this country review and its policy recommendations will help Greece in implementing its energy reforms successfully.

Dr. Fatih Birol

Executive Director

International Energy Agency

ENERGY SECURITY

ENERGY SYSTEM TRANSFORMATION

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Overview

Greece has made noticeable progress with energy sector reforms since the last IEA in-depth review in 2011, by restructuring state-owned companies and transposing provisions of the third European Union (EU) Energy Package for the liberalisation of electricity and natural gas markets. Competitive and financially viable energy markets, which offer choices and low prices to consumers, are critical for regaining economic growth and ensuring long-term economic prospects. The reforms will reveal opportunities for investors and for transformation of the energy system, thus providing sustainable outcomes for the environment and Greek society.

Greece is expected to achieve the 2020 emissions reduction and energy efficiency targets agreed with the European Union. This is partly due to its lower total final energy demand due to the economic crisis since 2010. Policies to support the use of energy from renewable sources (renewable energy) and energy efficiency have also contributed towards meeting these targets. Greece had the second-highest share of solar photovoltaics (PVs) in the total primary energy supply of all IEA countries in 2016.

Once the economy recovers, the current policies will not be adequate to guide the Greek energy sector towards the long-term energy transition that the government is aiming for. The country could use the economic recovery as an opportunity to get ahead with longer-term emissions reduction outcomes by pursuing initiatives that support sustainable increases in efficiency, and switching from oil and coal to natural gas and renewable energy. Key parts of this process will be to develop a national energy and climate plan for 2030 and beyond, and to incorporate climate objectives into integrated energy planning.

This review of Greece's energy policies has focuses on the two areas that will be integral parts of such an energy and climate strategy: renewable energy and energy efficiency.

Sector reform

Greece is going through a comprehensive reform programme that will result in an electricity market in which competitive prices will emerge with a level of regulatory maturity to attract investors. This will allow investors to trust that market outcomes will be the result of merit only.

The Greek authorities are commended for the significant efforts already made. It is now important to ensure that Greece implements these reforms in a timely manner. Greece

should opt for methods other than subsidising electricity prices to tackle energy poverty issues.

Greece has made important progress since the last review in liberalisation of the gas market through the introduction of a gas release programme. The market share of the dominant gas supplier is reduced in this programme through annual auctions of some of its supply portfolio to other market players. Another promising step is the ongoing liberalisation of retail markets, which promises a more-competitive environment and renewed impetus to the penetration of gas in the total fuel supply. The Greek authorities are commended for the efforts already made, which are important steps towards the emergence of a gas market that will eventually produce market outcomes attractive to end customers and investors alike. The authorities need to ensure the reforms in the gas market will be fully and timely implemented, like in the electricity sector.

The IEA welcomes Greece's efforts to ensure the implementation of electricity and gas market reforms and in preparing the regulatory framework for the introduction of an electricity target model in 2018.

The Regulatory Authority for Energy (RAE) has played an important role in providing the regulatory framework and secondary legislation for electricity and gas sector reforms. Energy sector laws have further empowered and enhanced the independence of RAE. Greece must ensure that RAE receives sufficient resources to undertake its growing responsibilities, given its role in ensuring competitive energy markets.

Energy security

Lignite is the only significant domestic fossil fuel in Greece, though its importance is decreasing in line with climate targets. Use of imported gas is still relatively low compared to other IEA countries, though its share in the total final consumption has doubled over the last decade. Greece has potential to significantly increase the use of gas for heating in the residential sector, by replacing inefficient oil and biomass systems. Greece also has a large potential for renewable energy use, with its wind, solar, geothermal, and biomass resources, which are not yet fully developed. Enhanced exploitation of this renewable energy potential will result in a more-balanced energy mix and contribute to increasing energy security.

Lignite has a record of being a reliable fuel source in the electricity sector, but has had a decreasing trend in electricity generation, compensated for by an increase in the shares of natural gas and renewables. However, it still plays an important role in the security of supply.

The relatively high share of oil use in power generation stems from thermal generation on the Greek islands that have no electricity interconnection to the mainland. Greece has initiated large interconnection projects as part of a long-term strategy.

The increasing role of gas in electricity generation requires a stronger focus on the security of gas supply. Greece has a small margin of system adequacy and relies on its only liquefied natural gas terminal for flexibility, which resulted in tight supplies during the winter of 2016/2017. The gas emergency response plan proved robust during the gas supply crisis, with power producers switching from gas to oil as requested.

There are several lessons to be learned from the gas crisis that should feed back into electricity and gas market design and the gas emergency plan. Demand response can provide an important source of system flexibility, if its activation is guided by price signals in a market designed to allow prices to reflect the real value of electricity and gas supplies when they are scarce. Price signals will be of growing importance when enhanced interconnections among Greece and neighbouring electricity and gas markets become operational.

Greece is actively involved in several international gas pipeline projects, aiming to establish itself as a gas hub in South Eastern Europe. These pipelines could increase the security of gas supply and would allow expansion of the domestic gas network into unserved areas in a cost-effective manner. However, the financial and economic viability of these projects needs assessment in a broader European context, to ensure that there will not be any over-capacity, to the detriment of consumer interests. The IEA encourages Greece to take a proactive and leading role in co-ordination of planning, trading policies, and regulations of the national markets, to establish a common regulatory framework for a gas hub.

Greece has complied with the IEA 90-day oil stock holding obligation since 2004. Diversification of oil and gas import sources has been successful, although a few import sources still dominate the market. Greece revised its emergency action plan for tackling serious oil supply disruptions in 2013, and included a list of indicative measures such as demand restraint measures.

Energy system transformation

The Greek energy mix is defined by high oil use in the heating and transport sectors, and, until recently, also high lignite use in power generation. However, Greece has had an impressive increase in wind and solar PV power generation from 2010 to 2015, amounting to almost 300%, and the share of renewable energy generation was just under 30% of the total energy generation in 2015.

There is potential for other renewable energy, including geothermal, biomass (possibly co-firing with lignite), and concentrated solar power, and for its use in other sectors, such as industrial heat and transport. Greece has seen a reduction in greenhouse gas (GHG) emissions, amid decreasing gross domestic product and energy demand. Emissions have decreased at a higher rate than energy consumption, owing to the increase of renewable energy sources and natural gas. However, the carbon intensity of the power sector remains above the IEA average.

Greece has put in place policies that incentivise or support energy conservation, energy efficiency, or the use of renewable energy, which thereby contribute to its GHG emission mitigation efforts. However, a longer-term energy and climate strategy is required now the Paris Agreement has entered into force. The IEA encourages the Greek authorities to expedite finalisation of a national energy and climate plan, as part of the EU 2030 Energy and Climate Framework.

Special focus 1: Renewable energy

Greece has seen an impressive increase in the share of renewables in electricity generation, even overachieving the set targets for solar PVs, since the last IEA review in 2011. Wind power capacity has increased significantly, although it has been below the expectations set previously. This success has been due to generous feed-in-tariffs and decreasing technology costs.

The costs of the support programme became exorbitantly high, and Greece has taken corrective measures. It has put in place a new legal framework for the support of renewable electricity and high-efficiency co-generation through a market-based feed-in premium programme. However, some regulatory and government decisions are yet to be finalised before tenders under the new programme can be launched; this is affecting the addition of new renewable power capacities. The IEA urges the Greek authorities to speed up the issuance of required regulations and decisions to shorten the gap between the phase out of the old and introduction of the new support programmes. Greece may consider gradually phasing out additional support on top of the electricity market value for some renewable sources after 2020 as technologies mature, because technology costs are decreasing rapidly and competitive auctions are likely to reduce costs.

Speeding up and simplifying complex licensing and permitting processes has been part of Greece's success in achieving the penetration of renewable energy generation. However, it needs to do more to reduce the multiple administrative layers, and the preparation of a detailed timeline for future auctions is advisable. Greek authorities are reviewing the environmental impact assessment (EIA) framework, with the aims to reduce the number of projects requiring an EIA and the time needed for an EIA. These are expected to stimulate investments, and the IEA encourages the authorities to bring this review to an early conclusion to provide certainty for investors.

There is high potential for renewable energy on Greece's non-interconnected islands (NIIs). However, only around 10% of the total installed renewable capacity (excluding hydro) is located on the NIIs. This is due to seasonal demand, absence of storage, and technical restrictions related to the variable nature of wind and solar. Greece therefore needs to move its focus towards either the integration of non-interconnected systems into the mainland transmission system or the enhanced installation of storage systems, based on their economic and technical feasibility.

Interconnections are critical for the government's energy policy, to enhance the security of electricity supply and to support the development of renewable energy sources so that Greece can meet its renewable energy and GHG reduction targets. The isolated systems rely to a large degree on expensive diesel generators, which have a detrimental effect on the environment.

It is also important for Greece to explore renewable energy sources beyond solar and wind and to increase their usage in the non-electricity sector as an integral part of the national energy and climate plan under preparation.

Greece's progress in decarbonising transport remains challenging, as in other EU member states. Greece has a blending requirement for diesel but not for gasoline. Diesel blending is achieved by using first-generation biofuels, which will become difficult under future EU rules that aim to limit contributions from such unsustainable biofuels. There is

almost no deployment of electric or hydrogen vehicles in Greece. Construction of alternative fuel infrastructures is needed to boost the share of alternative fuel vehicles, but the costs appear prohibitive under current economic conditions.

Special focus 2: Energy efficiency

Greece has implemented several energy efficiency policies during the period since the last IEA review, the majority of which are due to the transposition of requirements from the European Commission's Energy Efficiency Directive into Greek law. Implemented policy measures have not provided energy savings in line with initial expectations, due to the financial and economic crisis, low public awareness, insufficient data, and lack of funding.

Greece implemented an energy efficiency obligation programme in January 2017 that requires energy suppliers to make savings in line with an annual target, identified based on the market share of the obligated entity. The programme includes oil suppliers and subsequently the transport sector. Inclusion of the transport sector is not common in other countries with similar obligation programmes, due to the limited relationship that oil suppliers have with end users. Greece will need to work jointly with oil suppliers to ensure that the sector complies with its obligations.

The recent implementation of an energy audit policy is a step forwards for industrial energy efficiency in Greece. This presents an opportunity for energy suppliers to work with industry to undertake energy audits and to identify and implement efficiency opportunities, because there are synergies with the introduction of the obligation programme.

Limited new construction since 2010 has hindered the effectiveness of energy efficiency measures for buildings, and there is potential for Greece to improve the efficiency of its building stock. Efficiency measures, such as improvements in thermal insulation and replacement of oil heaters, will create multiple economic and social benefits. The high rate of building ownership presents opportunities as barriers to renovation are reduced. However, the large percentage of building stock that is either unoccupied or temporarily occupied presents a challenge.

Greece's reduction in energy use due to the economic crisis masks the minimal improvements made in energy intensity since 2000. Greece should pursue the implementation of ambitious energy efficiency policies, drawing on the evaluation of outcomes from past and current measures.

There is no tradition of conducting *ex ante* cost-benefit analysis of proposed measures, which makes evaluation of the impact of energy efficiency policies challenging. Reporting obligations from the energy audit policy will provide data that can help to inform prospective investors, to give an understanding of the country's energy efficiency market. This could be used for the design of future industrial energy efficiency policies. Developing and implementing a methodology for undertaking complete baseline assessments of expected cost-benefits of energy efficiency policies is important, and Greece would benefit from lessons learned by other countries on measuring and verifying benefits.

Key recommendations

The government of Greece should:

- Develop an integrated national energy and climate policy framework for 2030 and beyond; this should facilitate energy system transformation in a recovering economy while advancing market reforms and setting ambitious renewable energy and energy efficiency targets.
- Continue to prioritise implementation of gas and power sector reforms to support the creation of competitive and financially viable markets that provide energy at least cost and promote energy security.
- Actively pursue interconnections of NIIs with the mainland transmission system to use the strong renewable energy potential; this would achieve multiple energy policy objectives including meeting environmental and climate goals and enhancing energy security.
- Continue the implementation of ambitious energy efficiency policies, drawing on the evaluation of outcomes from past and current measures, and introduce a comprehensive *ex ante* cost-benefit analysis.
- Ensure regulator capacity to carry out reform and oversight, and ensure sufficient staff strength.

1. General energy policy

Key data

(2016 provisional)

TPES: 22.9 Mtoe (oil 50.0%, coal 19.0%, natural gas 15.2%, biofuels and waste 6.1%, hydro 2.1%, solar 2.3%, wind 1.9%, electricity imports 3.3%), -24% since 2006

TPES per capita: 2.1 toe (IEA average: 4.4 toe)

TPES per unit of GDP: 0.09 toe per USD 1 000 PPP (IEA average: 0.109 toe per USD 1 000 PPP)

Energy production: 6.8 Mtoe (coal 58.0%, biofuels and waste 18.3%, solar 7.9%, hydro 7.0%, wind 6.5%, oil 2.2%, natural gas 0.1%, geothermal 0.1%), -32% since 2006

Country overview

Greece is located in South Eastern Europe, and shares borders with Albania, the Former Yugoslav Republic of Macedonia, Bulgaria, and Turkey. It covers 131 957 square kilometres with a coastline of 13 600 kilometres, the longest in the Mediterranean basin, bordering the Aegean Sea, Ionian Sea, and Eastern Mediterranean Sea. The three main areas of Greece are the mainland, the Peloponnese peninsula, which is separated from the mainland by the Corinth Isthmus canal, and around 6 000 islands and islets, of which only 227 are inhabited. About one-third of the population of 10.7 million lives in the Attica region, located around Athens. The rest of the country is sparsely populated, with the exception of certain urban agglomerations like Thessaloniki. Eighty percent of the country consists of mountains or hills.

Greece is a parliamentary democracy with a president as the head of state. The executive powers rest with the government, which is led by a prime minister. Executive functions are exercised by members of parliament, who are appointed by the prime minister to the cabinet. The Coalition of the Radical Left (SYRIZA) won the last parliamentary election in 2015 and forms the government jointly with the Independent Greeks (ANEL).

The Greek economy relies primarily on the service sector, which accounts for over 80% of the gross domestic product (GDP). The industry sector accounts for less than 15%, and the rest is made up of the primary sector (agriculture, fisheries, and forestry). Tourism, the public sector, and shipping dominate within the service sector. The public sector accounts for 40% of the GDP. Greece recorded a GDP growth of 0.3% in 2016, after years of economic contraction, primarily due to a strongly performing tourism sector and good industrial output. The labour market is also showing signs of a slow recovery. Employment was up by approximately 2% in 2016 over the previous year (2015). Total unemployment was about 21.2% in June 2017.

Figure 1.1 Map of Greece

This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Economic reform programme

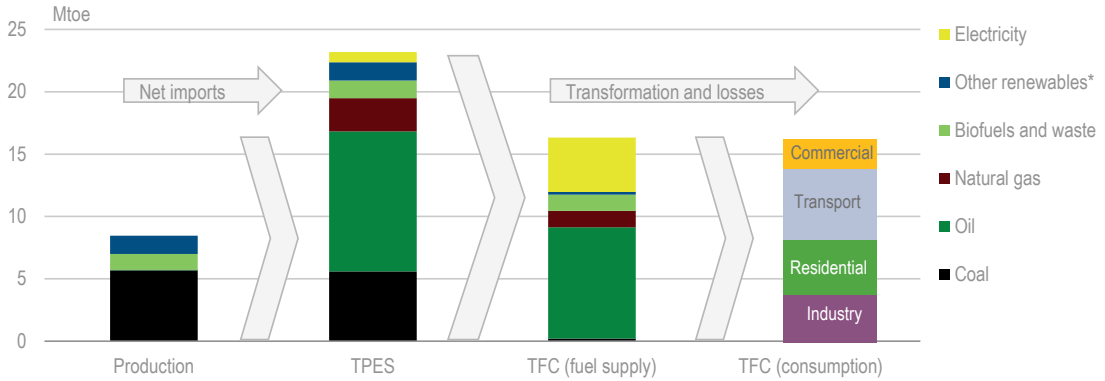
The country's financial crisis, which began in 2009, resulted in the government agreeing on an economic adjustment programme (EAP) with the European Union, the International Monetary Fund, and the European Central Bank in 2010. The liberalisation of product markets and the increase of competition in the energy sector are some of the key aspects of the EAP. Divestment of state-owned assets, including in the energy sector, is a requirement of the EAP and has been rolled-over into the second (2012) and third (2015) EAPs. The EAPs provide for full privatisation and liberalisation of the gas and electricity markets.

The provisions in the EAP contribute towards making the energy sector more competitive, bringing it in line with the third European Union (EU) Energy Directive and EU best practices for the energy sector.

Supply and demand

Greece has a large amount of coal production that covers the domestic demand for coal, which is used mainly in the power sector. Coal is still the dominant fuel in electricity generation, accounting for almost a third of the total generation, but its use is decreasing. Oil is the most-significant fuel, and the country is almost entirely dependent on oil imports. The transport sector, which is the largest energy-consuming sector, is dominated by oil products, and large shares of fuel oil are being used in the residential sector (see Figure 1.2).

Figure 1.2 Overview of energy production, total primary energy supply (TPES), and total fuel consumption (TFC), 2015



* *Other renewables* includes hydro, solar, and wind.

Source: IEA (2017), *World Energy Balances 2017*, www.iea.org/statistics/.

Primary energy supply

Greece's total primary energy supply (TPES[1]) decreased by 24% from 2006 to 2016, mainly due to the economic crisis in the country after 2009.

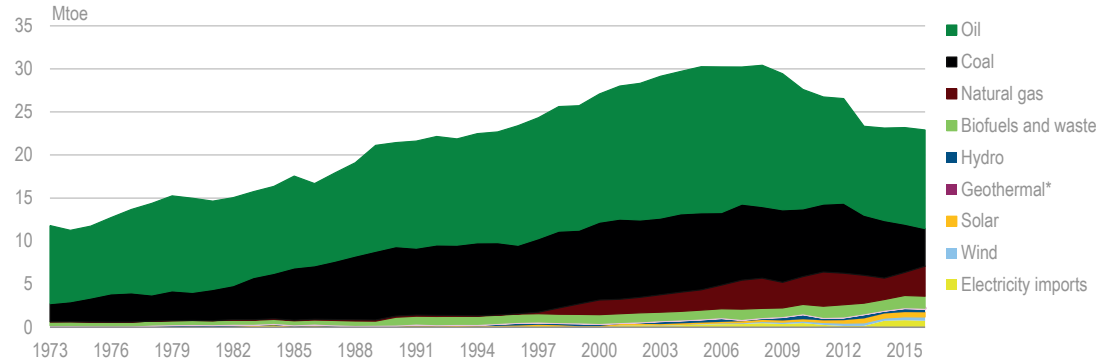
Oil is the dominant fuel in Greece, accounting for half of TPES in 2016, though the total oil supply has fallen by almost a third since 2006. The share of oil in TPES is the second-highest among IEA member countries, after Luxembourg, which is dominated by the transport sector and "fuel tourism" from its neighbouring countries.

Coal is the second most dominant fuel used in Greece, accounting for 19% of TPES in 2016. It is mainly used in electricity generation plus a small share in the industry sector. Coal supply has nearly halved over the past decade, from 8.4 million tonnes of oil equivalent (Mtoe) in 2006 to 4.4 Mtoe in 2016, due to decreasing use of coal-powered plants. Greece introduced natural gas into its energy system in the late 1990s, and it became the third most dominant primary fuel in 2016, accounting for 15% of TPES. The supply of natural gas peaked at 4.0 Mtoe in 2011, and has fallen by 12% since, to 3.5 Mtoe in 2016 (see Figure 1.3).

[1] TPES is made up of 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. power generation and refining) or in final use.

Greece had an 84% fossil fuel share in TPES in 2016, which was the seventh-highest share among IEA member countries (see Figure 1.4).

Figure 1.3 TPES by source, 1973-2016

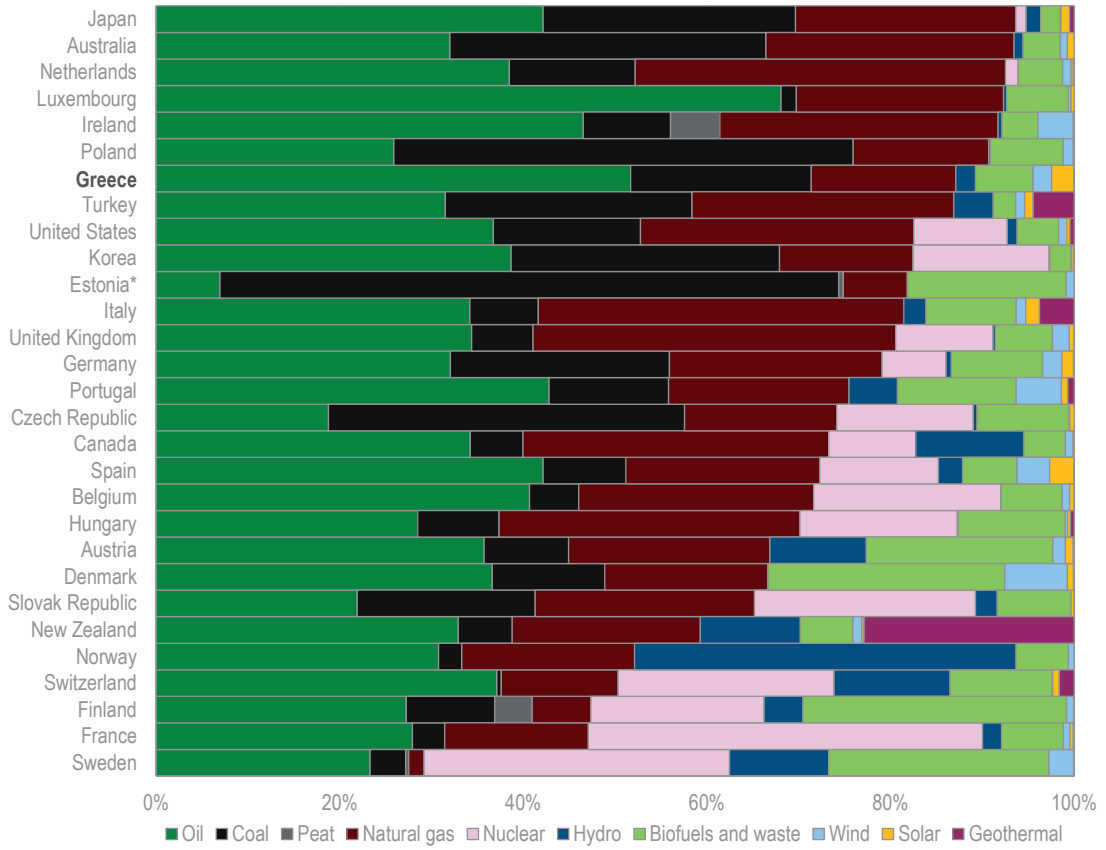


* Negligible.

Note: Data are provisional for 2016.

Source: IEA (2017), *World Energy Balances 2017*, www.iea.org/statistics/.

Figure 1.4 Breakdown of TPES in IEA member countries, 2016



* Estonia's coal is represented by oil shale.

Note: Data are provisional.

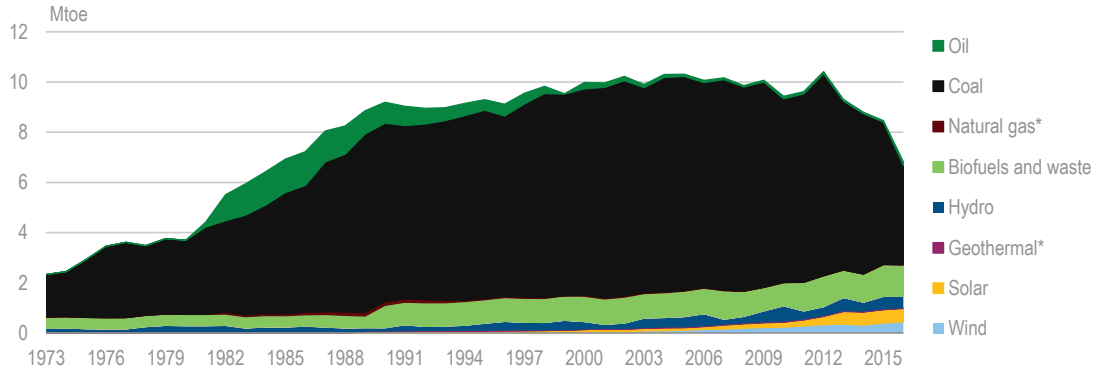
Source: IEA (2017), *World Energy Balances 2017*, www.iea.org/statistics/.

The share of energy generated from renewable sources (renewables) is small, but more than doubled from 5.9% in 2006 to 12.5% in 2016. Biofuels and waste[2] account for almost half of renewables in TPES, mostly primary solid biofuels used in the residential sector, but the growth in renewables in the last decade is a result of rapid increases in wind and solar power generation. The share of solar energy in TPES is the second highest among IEA member countries, after Spain.

Energy production and self-sufficiency

Coal production dropped by 30% in 2016 compared to 2015, but still accounted for over half of the total energy production in Greece (see Figure 1.5). The remaining energy production comes from renewable energy sources, of which biofuels and waste production accounts for the largest share, followed by solar, hydro, and wind. Oil production peaked at around 1.3 Mtoe in the mid-1980s, but has since decreased to negligible levels.

Figure 1.5 Energy production by source, 1973-2016



* Negligible.

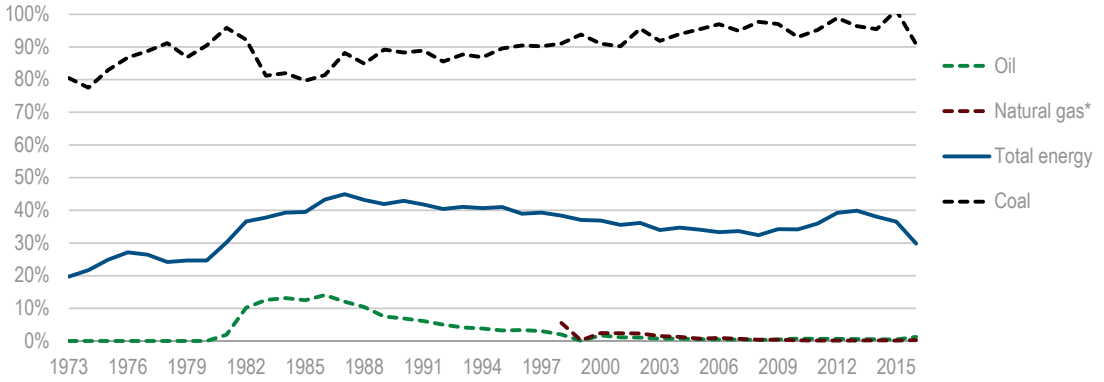
Note: Data are provisional for 2016.

Source: IEA (2017), *World Energy Balances 2017*, www.iea.org/statistics/.

A large amount of lignite production enables Greece to be nearly self-sufficient in coal consumption (see Figure 1.6). However, insignificant crude oil and natural gas production leaves Greece reliant on imports for those fuels. The total energy production accounts for less than one-third of TPES in the country. The Russian Federation is the largest supplier of natural gas to Greece and the second-largest source of crude oil after Iraq.

[2] Biofuels and waste includes primary solid biofuel (e.g. wood chips or firewood), charcoal, biogas, and liquid biofuels (mainly biodiesels in Greece), plus municipal and industrial waste (no municipal waste is used as energy in Greece).

Figure 1.6 Self-sufficiency by fuel (production as a share of TPES), 1973-2016



* Natural gas numbers start at 1998, because gas supply was very low before then.
Note: Data are provisional for 2016.
Source: IEA (2017), *World Energy Balances 2017*, www.iea.org/statistics/.

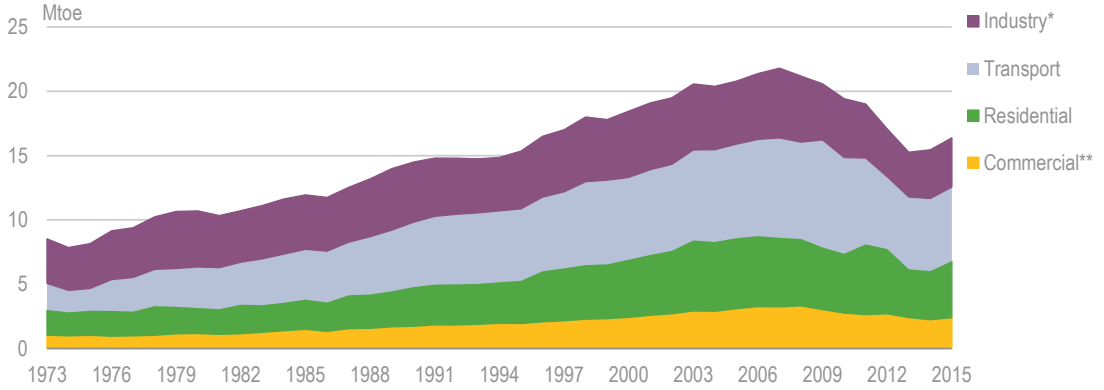
Demand

Greece's total final consumption (TFC)[3] decreased by 30%, from a peak level of 21.8 Mtoe in 2007 to 15.3 Mtoe in 2013, because of the economic downturn after the financial crisis. TFC picked up slightly in 2015, to 16.4 Mtoe (see Figure 1.7).

The transport sector is the largest energy consumer, accounting for 35% of TFC, followed by the residential (27%), industry (23%), and commercial (15%) sectors. The final energy consumption of all sectors has decreased similarly over the last decade, with industry showing the largest fall by 29% from the peak in 2007.

Oil accounts for over half of the energy in TFC, mainly because of its dominance in transport and large shares in the industry and residential sectors (see Figure 1.8). Electricity is the second-highest energy source, especially in the commercial sector.

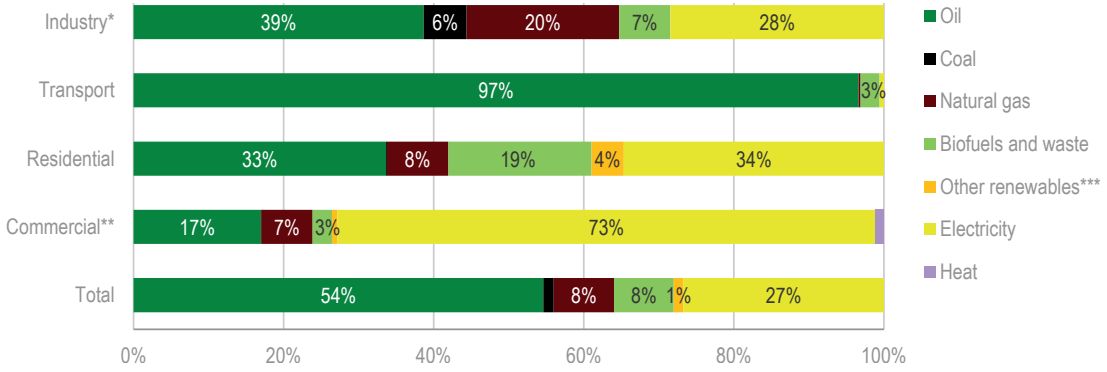
Figure 1.7 TFC by sector, 1973-2015



* *Industry* includes non-energy use.
** *Commercial* includes commercial and public services, agriculture, fishing, and forestry.
Source: IEA (2017), *World Energy Balances 2017*, www.iea.org/statistics/.

[3] TFC is the final consumption of fuels (e.g. electricity, heat, gas, and oil products) by end user, not including the transformation sector (e.g. power generation and refining).

Figure 1.8 Fuel share of TFC by sector, 2015



* *Industry* includes non-energy use.

** *Commercial* includes commercial and public services, agriculture, fishing, and forestry.

*** *Other renewables* includes solar and geothermal.

Source: IEA (2017), *World Energy Balances 2017*, www.iea.org/statistics/.

Key institutions

The **Ministry of Environment and Energy** is responsible for environment, energy, and climate change policy within the government. Within the ministry, the Directorate for Energy is responsible for energy policy and energy statistics. The ministry is also responsible for the development of renewable energy and energy efficiency policy, and it supervises the **Centre for Renewable Energy Sources and Saving (CRES)**. The ministry supervises 48 institutional bodies, including public sector energy companies.

The **Ministry of Finance** is responsible for taxation, including energy taxation, and other fiscal matters, and oversees the Hellenic Competition Commission (HCC) and other bodies.

The **Regulatory Authority for Energy (RAE)** is an independent authority with financial and administrative independence for all energy markets. It has gained direct powers over time, including the right of a consenting opinion for the National Gas and Electricity Grid Operation Code, the Power Exchanges Code, and the Gas and Power Distribution Network Operation Code. RAE also approves methodologies and details for the implementation of operation codes and is responsible for licensing, market control, and supervision.

The **Hellenic Competition Commission (HCC)** is an independent authority to oversee the proper functioning of market competition in Greece. It can make inquiries into market power or market abuse, and it acts as an advisory body to the government. HCC is overseen by the Ministry for Finance, but it is financially and operationally independent.

The **Hellenic Republic Asset Development Fund (HRADF)** implements the privatisation of state assets in accordance with international obligations and the medium-term fiscal strategy of the Greek Government. All or part of the state shares held in **Public Power Corporation S.A. (PPC)**, **Public Gas Corporation S.A. (DEPA)**, and **Hellenic Petroleum (HELPE)** have been transferred to HRADF.

The **Centre for Renewable Energy Sources and Saving (CRES)** is the national centre for renewable energy sources, rational use of energy, and energy saving, and it

co-ordinates national policies in these areas. It also produces energy systems analysis and is active in EU-funded projects. CRES is supervised by the Ministry of Environment and Energy.

The **Public Power Corporation S.A. (PPC)** is a majority state-owned vertically integrated electricity company, which holds assets in lignite mines, power generation, transmission, and distribution. PPC's power generation capacity accounted for about 68% of the total installed capacity in Greece in 2016. The Independent Power Transmission Operator (ADMIE) and the Hellenic Electricity Distribution Network Operator (HEDNO) were created as two 100% subsidiaries of PPC in 2012.A 24% share in ADMIE has recently been sold to a strategic investor.

The **Public Gas Corporation S.A. (DEPA)** is a state-owned vertically integrated natural gas company that provides about 90% of the gas in Greece. DEPA owns the Hellenic Gas Transmission System Operator (DESFA), it is the owner and operator of the high-pressure transmission network of natural gas, and owns the country's only liquefied natural gas (LNG) terminal. DEPA also owns 51% of the regional gas distribution and supply companies (EPAs), it is the owner of the newly created gas distribution company DEDA (Gas Distribution Company Rest of Greece), and it holds 50% of the Interconnector Greece-Italy (IGI Poseidon).

The **Hellenic Petroleum S.A. (HELPE)** is the country's leading oil importer, refiner (65% market share), and retailer (over 30% market share). HELPE owns a 35% share in DEPA, and HRADF holds a 35.5% share in HELPE.

The **Hellenic Hydrocarbons Resources Management S.A. (HHRM)**, established in 2011, is the authority for exploration and exploitation of the hydrocarbons sector, overseen by the Ministry of Environment and Energy. HHRM has been the transitional authority for offshore safety since 2016, until a new authority can be established.

Key policies

The government's declared policy is to diversify energy sources and reduce the carbon dioxide (CO_2) intensity of the economy while increasing energy security and implementing comprehensive energy market reforms to make the sector more competitive.

Sector reform

The energy sector in Greece is dominated by state-owned enterprises and lacks sufficient competition. There is also a question about the commercial operation of the energy sector that is required to undertake public service obligations (PSOs) without sufficient compensation in a timely manner, for example, through social tariffs and acting as collector of non-energy-related charges. Therefore, reforms in the energy sector are expected to have a positive effect on its commercial functioning.

Greece has been making considerable progress towards reforming the energy sector compared to the situation before the first EAP. The Ministry of Environment and Energy has prepared, and the parliament has passed, laws that provide an umbrella framework for the necessary reforms. These reforms include increasing competition in the electricity and gas wholesale and retail sectors by transposing the third EU Electricity and Natural

Gas Market Directives into national law (4001/2011). Laws 4336/2015, 4337/2015, 4414/2016 (on the unbundling of supply operation of distribution grids), 4414/2016 (on a new renewable energy source support programme), and 4425/2016 (on an electricity target model) have continuously strengthened the legal basis and have put the country on a trajectory to meet the requirements set under the third EU Energy Directive.

Key energy sector companies are characterised by their vertical integration across the energy value chain. Hence, the divestment and eventual privatisation of energy sector companies will proceed in phases by first selling off defined business units such as the transmission segment, which allow for proper valuation and that contribute to an effective unbundling in the sector. The government transferred almost its entire stakes in energy sector companies to the purposely created HRADF, which it formed in 2011 to implement the privatisation of state assets in close cooperation with the Greek government.

Box 1.1 Roles of RAE and HCC

A key driver of the progress made with energy sector reforms is the work of the sector regulator RAE, who has put into place the regulatory framework and secondary legislation required to implement government policy and laws. New energy sector laws (4001/2011, 4336/2015, and 4414/2016) gave RAE greater powers and independence, including financial independence and a distinct legal status. RAE revised the natural gas licensing regulation in a timely manner to provide for the new types of licensing required for the unbundling of distribution and supply activities. It also concluded the first revision of gas tariff regulation following two extensive rounds of public consultations. RAE has successfully monitored three NOME* auctions in the electricity sector, to reduce the dominant market share of PPC, and is working in collaboration with the Ministry of Environment and Energy and other energy sector actors to prepare the introduction of a new electricity market model in 2018.

HCC has opted for a non-confrontational approach in using its mandate to enhance competition. It aims to obtain firm commitments, from the companies under investigation, to certain actions without levying sanctions and fines. The gas release programme of DEPA, to increase liquidity in gas supply, is one of the settlements reached. HCC investigated DEPA following a third-party complaint about abuse of DEPA's dominant market position. To avoid a fine from the HCC, DEPA offered commitments to provide a higher degree of customer mobility and liquidity in the natural gas market through an electronic auction system. HCC accepted this commitment, and regular auctions have been held since 2012 (see Chapter 6).RAE has been subject to salary cuts and a hiring freeze that applies to all public sector entities, unlike HCC. This is affecting RAE's ability to perform its growing duties and responsibilities in a timely manner. The 2016 supplementary memorandum of understanding among Greece, its European partners, and the International Monetary Fund calls for the adoption of legislation to strengthen the institutional, financial, and functional independence of RAE.

* NOME is the acronym for Nouvelle Organisation due Marché de l'Electricité.

The government's first attempt to sell off a two-thirds share in DESFA concluded unsuccessfully in late 2016, also as a result of European Commission guidelines. However, reforms of the natural gas distribution segment and the strengthening of regional interconnections have shown promising developments. The full liberalisation of retail markets is on track to meet the agreed deadline of 1 January 2018 (see Chapter 3).

The sale of a 24% share in the Hellenic Power Transmission System Operator, ADMIE, was finalised in June 2017. This is an important step towards improving competition and prospects for investment in the power sector. Other policy and regulatory initiatives to increase competition in the electricity sector are ongoing, and are also showing encouraging results. Among these are the gas and electricity auctions to advance competition in these two wholesale markets (see Chapters 3 and 4).

Security of supply

Greece imports almost 100% of its oil and gas supply, which accounts for nearly two-thirds of TPES. Security of supply therefore remains a top policy priority of the government. Greece has complied with the IEA 90-day stock holding obligation since 2004. Diversification of oil and gas import sources has been successful, with a reduction in dependence on oil imports from the Organization of the Petroleum Exporting Countries and gas imports from the Russian Federation, although these two import sources still dominate the market.

The increasing role of natural gas in the energy sector has resulted in the formulation of gas security strategies for the short and medium terms. The country is not meeting the N-1 criteria [4] and relies on demand-side measures during a gas emergency. The government is pursuing international gas pipeline projects to enhance medium-term security of gas supply, with a view to establishing the country as a gas hub in South Eastern Europe. The storage capacity of the country's only LNG facility is being expanded by 40%. During a supply crisis, the country will execute its recently revised gas emergency response plan, which relies on demand-side reduction, fuel switching, and deploying of the commercial gas reserves held at the LNG terminal. The 2016/2017 winter gas crisis emphasised that the country remains vulnerable to disruption at its largest gas infrastructure, the LNG terminal, and that expansion of the storage facilities is of key importance to assure security of supply. The crisis also exposed the close interlinkages between the gas and electricity supply and the importance of allowing markets to react to price signals.

Greece is self-sufficient in lignite production. It also has a large potential for variable renewable energy sources, which are playing an increasing role in electricity supply, accounting for 16% of electricity generation in 2015. Increasing the share of variable renewables offers a large economic potential, but also requires ensuring sufficient flexibility of the transmission system. Greece is a net importer of electricity and is pursuing plans to increase interconnections with its neighbouring countries, especially with regard to meeting peak electricity demand.

[4] The N-1 formula describes the ability of the technical capacity of the gas infrastructure to satisfy total gas demand in the event of disruption of the single-largest gas infrastructure during a day of exceptionally high gas demand.

Climate policies and taxation

Greece ratified the Paris Agreement in October 2016 as part of the EU ratification process, but has not set any specific nationally determined contribution beyond the EU-wide target of at least a 40% domestic reduction in greenhouse gas (GHG) emissions by 2030, from the 1990 level.

The country's climate change targets are largely set by policies and measures under the EU 2020 Package and its national renewable and energy efficiency energy action plans of 2011 and 2008, respectively, which are regularly updated. Under the EU 2020 Package, Greece committed to an energy efficiency target of 24.7 Mtoe in primary energy consumption or 18.4 Mtoe of final energy consumption, with a national renewable energy target of 20%; this was 2% higher than the EU-wide target. Greece has made strong progress towards meeting the renewable energy target in electricity and heating, but not in transport. The country is well on track to meet its 2020 target, with a final energy consumption of 16 Mtoe in 2015, because energy demand has decreased substantially since 2008.

Greece is expected to achieve the 2020 emissions reduction targets, largely due to the decline in energy demand and the growth in renewable energy. However, the country's carbon intensity of power generation has not reduced in line with other EU member states. This can potentially become a challenge of climate policy, once the economy recovers.

The government clearly needs to develop a comprehensive energy and climate policy that goes beyond the EU target and that specifically takes into consideration ambitions for energy efficiency and renewable energy. Such a comprehensive policy would also support infrastructure planning by enhancing certainty for investors. It should be reflective of the domestic resource endowment and economic and environmental considerations, and aim to use the country's impressive skills base. The government's commitment to prepare a national energy and climate plan towards 2030, by the end of 2017, is commendable.

Energy sector taxation is one of the requirements of the EAPs. The main objective is to raise revenues for the government, but the measures also contribute towards introducing a system of taxation that promotes consideration of environmental and energy efficiency. One such example is the introduction of a motor vehicle registration tax that explicitly builds on CO_2 emissions and Euro auto emission performance standards in addition to being levied at the retail and not the wholesale price.

Assessment

The IEA in-depth review comes at a time when the Greek financial and economic crisis has put significant stress on the government to implement a high number of reforms in a short time, both in the gas and power sectors to ensure the financial viability of the energy sector and to support economic growth. To have the IEA in-depth energy review in the midst of these difficult times is particularly challenging, but also timely, as input from the review can help to develop the new energy and climate plan for 2017 and to complete market reforms.

Greece is commended for advancing extensive energy sector reforms during this period of economic stress. Efforts to create a solid, competitive energy market and to expand infrastructure will be important for a robust, sustainable economic rebound and for enhancing energy security. The government has rightly identified that completing gas and power reforms is essential for enhancing competition, attracting investment, and achieving environmental targets.

The reforms require adequate planning and regulatory engagement, stability, and certainty. Supporting the financial and technical capacity of the authorities, namely, RAE and HCC, to carry out changes is essential to the pace and quality of market design efforts. Greece should strengthen the financial and functional independence of these authorities.

The wide range of reforms may raise co-ordination challenges. Optimising and calibrating gas, power, and other reform efforts requires integrated energy sector analysis that reflects interaction among policies and the cumulative impact on objectives, including energy costs and the environment. Keeping the financial viability of the energy sector in mind, the reforms should also aim to reduce subsidies and promote investments that can improve energy access and greater supply and security in the long term. The government's priority to interconnect islands with the mainland system offers the possibility to partially decrease the PSO levy that is paid by all electricity consumers to support the higher cost of electricity supply on non-interconnected islands. The corresponding increase in grid charges could contribute to partially financing the necessary investments.

Reforms will attract private energy sector investment, which can spur economic growth. Government and policy action should reveal opportunities for transformation of the energy system as an opportunity to gauge investments for economic growth and to encourage sustainable economic outcomes for society.

Greece designs all policies under the EU Energy and Climate Framework, which sets ambitious goals for renewable energy, energy efficiency, and reduction of GHG emissions. The country's energy sector policy focuses on these areas and on transformation of the energy market to enhance competition, alleviate energy poverty, and transition to a low-carbon economy. Greece's energy roadmap, which is under preparation, will therefore be based on three pillars: social engagement, long-term environmental sustainability, and economic development prospects.

Greece contributes to the EU-wide efforts to reduce GHG emissions by 20% by 2020, from 1990, through a renewable energy target of 18% (national target of 20%), under the EU-wide Emissions Trading System (ETS) and a national effort sharing, which requires Greece (EU Effort Sharing Decision) to reduce GHGs outside the EU-ETS by 4% by 2020. For 2020, Greece has set an energy efficiency target of 24.7 Mtoe in primary energy consumption or 18.4 Mtoe of final energy consumption. Greece has made good progress towards its renewable energy target in electricity and heating, but efforts are still needed in the transport sector. The energy efficiency target would allow for an increase in consumption from the energy consumption of 16 Mtoe in 2015.

Greece ratified the Paris Agreement in October 2016 (Law 4426/2016) as part of the EU ratification process for 2030. The country has no nationally determined contribution, because, as an EU member state, it is covered by the EU nationally determined contribution, which has to achieve at least a 40% domestic reduction in GHG emissions

by 2030, from the 1990 level. Outside of the EU-ETS, the European Commission proposed a new effort sharing target under the new Burden Sharing Proposal for 2021-30 (July 2016) that would require Greece to cut emissions by more than 16%, much higher than during the previous period.

Greece is expected to achieve the 2020 emissions reduction targets it has agreed to in the European Union. This is partly due to the policies applied, but is also due to the sharp decline in energy demand due to the economic crisis. Therefore, the structure and the carbon intensity of the Greek economy have not changed. The government has the opportunity to get ahead on longer-term emission outcomes now, by pursuing initiatives for sustainable increases in renewables and efficiency, and switching from oil and coal to fuels that are more environment friendly.

National policies to achieve this target will need development, notably the ambitions for emissions reduction outside the EU-ETS sector, energy efficiency, and renewable energy, as there are greater opportunities to identify national goals under the EU Clean Energy for All Package. It is understood that the government is preparing, by the end of 2017, a national energy and climate plan towards 2030 that will incorporate climate objectives into integrated energy planning.

Such a plan should set out a broader energy and climate framework to incentivise necessary investment from 2020 onwards, to enhance certainty for all stakeholders, both on the renewable and on the conventional generation side, and for infrastructure planning. The government should embed renewable energy and energy efficiency ambitions in the policy approach for emissions reductions, taking into account key parameters such as energy security and achieving lower costs across the energy sector.

Greece has a strong potential to become a gas hub for South Eastern Europe, due to its geographical location. The country's efforts to expand international gas pipelines, LNG and storage infrastructure, and power interconnections are critical to national and European energy security. Greece has defined strong policies in energy security, and benefits from a well-diversified oil supply, but efforts are still required to attain gas supply adequacy to avoid any effects on the power sector.

Greece supports strengthening the role of consumers and end user engagement, which can create niches in the market economy and accelerate innovative solutions. The government therefore plans to introduce a new legislative framework on energy co-operatives.

Recommendations

The government of Greece should:

- Continue to prioritise implementation of gas and power sector reforms, in particular, take measures to support the creation and operation of competitive markets, and promote energy security by attracting investments in support of Greece's ambition to become a gas hub for South Eastern Europe.

- ☐ Design a national, stable, and integrated energy and climate framework for 2030, based on the 2030 scenario outlook and national climate policy, in collaboration with stakeholders, to guide policies and review progress of the energy system transformation while advancing market reform.
- ☐ Ensure regulator capacity to carry out reform and oversight, and ensure sufficient staff strength.

References

IEA (International Energy Agency) (2017), *World Energy Balances 2017*, OECD/IEA, Paris, www.iea.org/statistics/.

2. Oil

Key data

(2016 estimated)

Crude oil production: 0.16 Mt, +71% since 2006

Net imports of crude oil: 28.2 Mt (28.4 Mt imported, 0.2 Mt exported)

Oil products production: 30.2 Mt, +36% since 2006

Net exports of oil products: 13.6 Mt (4.4 Mt imported, 18.1 Mt exported)

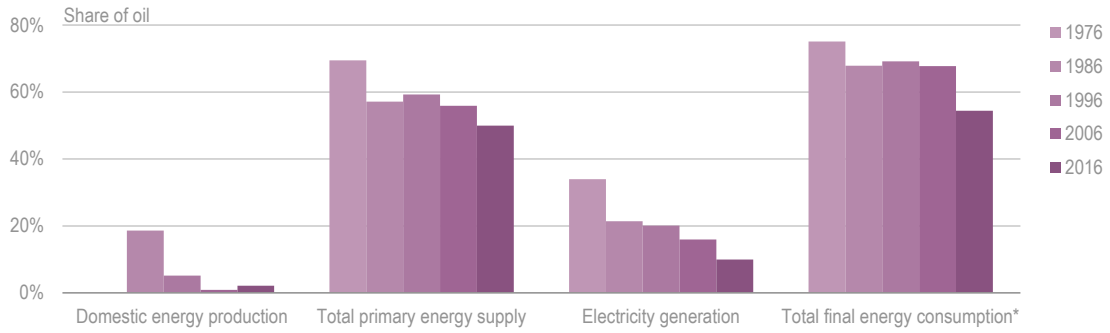
Share of oil: 50% of TPES and 54% of TFC (2015)

Consumption by sector: 11.2 Mtoe (transport 50.1%, heat and power generation 13.6%, industry 13.3%, residential 13.2%, other industry 6.1%, commercial 3.7%)

Overview

Oil is the most important fuel in Greece's energy system, accounting for half of the total primary energy supply (TPES) and over half of the total final consumption (TFC). However, the trend for oil consumption has been decreasing over the last decade, including in electricity generation (see Figure 2.1). Many poorer households receive subsidies for heating oil, and Greece's share of oil products in the residential sector is relatively high. Greece currently has negligible domestic crude oil production and is thus completely dependent on imports, mainly from Iraq and the Russian Federation. Greece is a net exporter of oil products thanks to its strong refinery capacity, despite its low crude oil production.

Figure 2.1 Oil share in energy supplies, 1976-2016



*Consumption data are for 2015.

Note: Data are provisional for 2016.

Source: IEA (2017a), *World Energy Balances 2017*, www.iea.org/statistics/.

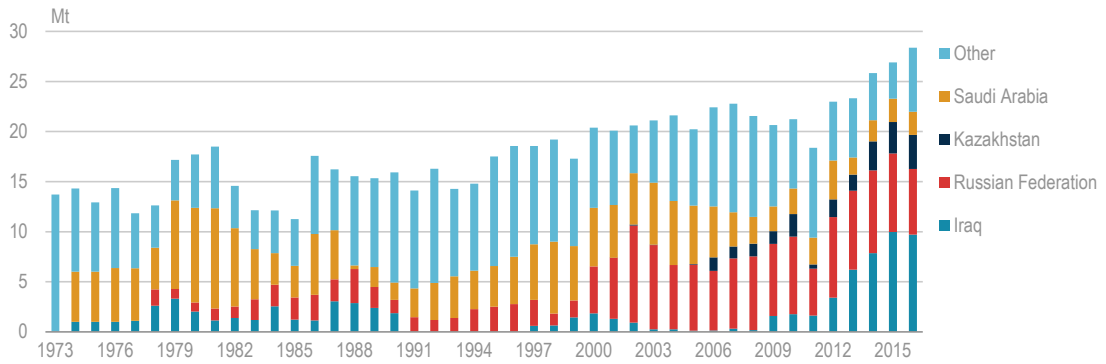
Supply and demand

Production, imports, and exports

Crude oil production in Greece was insignificant compared to the domestic oil product consumption of 11 million tonnes (Mt) in 2015. The country is thus dependent on large crude oil imports. Iraq was the largest supplier of crude oil in 2016, with 10 Mt, followed by the Russian Federation with 7 Mt. These two countries accounted for over half of the total crude oil imports to Greece (see Figure 2.2). Total crude oil imports increased by 27% from 2006 to 2016.

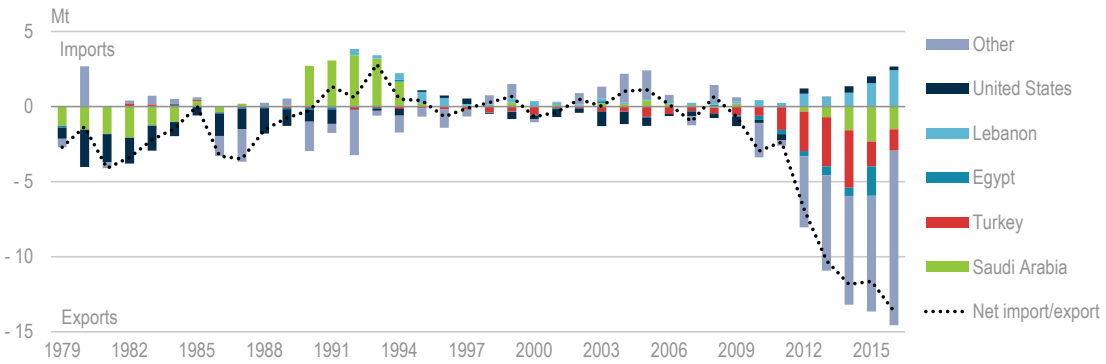
Imported crude oil is refined into oil products in four domestic refineries. Greece has increased its refining output in recent years, and the net export of oil products has grown fivefold in the five years from 2011 to 2016 (see Figure 2.3). The increased export of oil products correlates with the recent growth in crude oil imports in recent years. Greece also imports petroleum products. Product imports decreased by 32% over the period 2011-16, while crude oil imports increased by 54%.

Figure 2.2 Crude oil imports by country, 1973-2016



Note: Crude oil including natural gas liquids and feedstock. Data are provisional for 2016.
Source: IEA (2017b), *Oil Information 2017*, www.iea.org/statistics/.

Figure 2.3 Oil product imports and exports by country, 1979-2016



Note: Data are provisional for 2016.
Source: IEA (2017b), *Oil Information 2017*, www.iea.org/statistics/.

Private company Energean Oil and Gas SA is the country's only oil producer. The two producing fields, Prinos and North Prinos, are located offshore in the North Aegean Sea in eastern Greece. Production from Prinos is expected to double from the current 5 000 barrels per day, once the ongoing drilling programme for 15 additional wells has been completed in late 2017.

The Greek government is actively promoting hydrocarbon exploration activity with the aim of improving energy security and supporting economic growth. Law 4001/2011 updated the legal framework and created a new state authority for promotion of the hydrocarbon upstream sector: the Hellenic Hydrocarbon Resources Management, S.A. (HHRM), overseen by the Ministry of Environment and Energy. HHRM organises licensing rounds and is building a seismic data library available to potential investors. HHRM finalised a large-scale seismic survey covering an offshore area of western Greece and southern Crete in 2013, and it is also reprocessing existing data.

The government launched an open tender in 2012, and in 2014, it signed three exploration licences for one onshore and two offshore blocks. It granted a 25-year exploitation licence in 2016 for an area in the offshore Katakolo block, licensed to a 60:40 joint venture of Energean Oil & Gas SA and Trajan Oil & Gas. A field development plan is under approval. Energean SA expects production from the block to start by 2019/20, but no quantitative production targets have yet been announced.

The government launched two further licensing rounds, for 3 onshore and 20 offshore blocks, in 2014. Hellenic Petroleum (HELPE), the country's largest oil importer in which the state owns a one-third share, won the lease agreements for two onshore blocks, and Energean won the third onshore block. These two companies signed lease agreements in May 2017. Energean SA reached an agreement to farm out 60% of its interest in the onshore Aitoloakanania block and its onshore Ionannina block, from the 2012 licensing round, to Repsol SA of Italy. Finalisation of the deal is pending government agreement. Repsol would be the operator of the two blocks that are located in the Ionian basin in western Greece.

The government received only two bids for the offshore blocks. HELPE was involved in both bids: one was on a stand-alone basis and the second as part of a consortium including TOTAL Exploration and Edison Greece. Lease agreements for the two blocks are expected to be signed in the second half of 2017. Exxon Mobile is developing a strategic co-operation agreement with HELPE for future joint hydrocarbon exploration activities. Encouraged by these signs of new confidence in the Greek upstream sector, HHRM is planning to launch a new bidding round in 2018, reoffering those offshore blocks that did not receive bids in the 2014 auction and inviting bids for new exploration onshore blocks in northern Greece.

Domestic oil production from these six new blocks being explored will likely not be sufficient to significantly reduce Greece's import dependency. But the confidence shown by investors in the Greek economy could be an important catalyst for further investment in the energy sector and beyond. It is therefore critical for Greece to reach an early conclusion of the ongoing licensing rounds and to ensure the shortest possible time delay in the call for bids, the announcement of winners, and the signing of licences.

Consumption

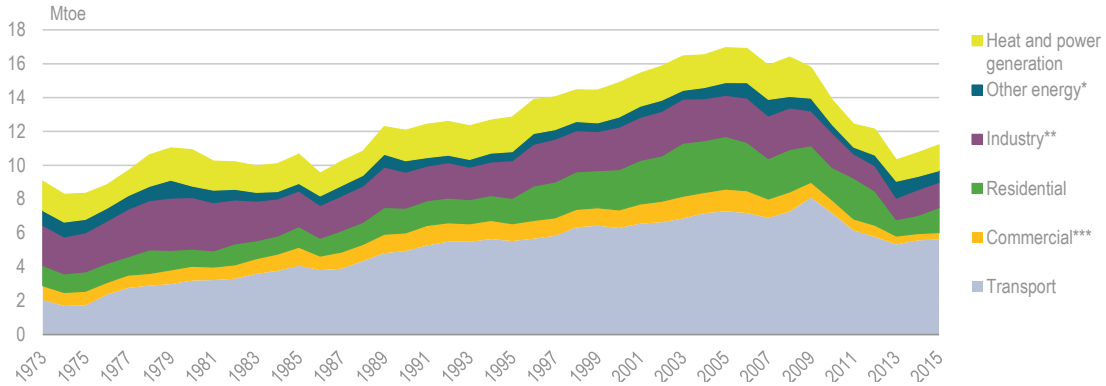
Oil consumption fell by one-third in the period 2005-15 because of the large drop after the financial crisis in 2008 (see Figure 2.4). Oil consumption has recovered slightly in the last few years, with a 9% increase from 2013 to 2015, mostly in the residential sector.

The transport sector consumed 5.6 million tonnes of oil equivalent (Mtoe) of oil in 2015, accounting for half of the total oil consumption. Road transport accounts for 87% of oil consumption in transport, followed by domestic shipping with 10%, and small shares of domestic aviation and rail transport. The transport sector consumes mainly diesel and gasoline, which together account for 62% of the total oil consumption in Greece (in terms of mass units, i.e. tonnes of oil products, rather than energy content, see Figure 2.5).

Around one-third of diesel oil is consumed in the residential sector for heating purposes. Heating oil accounts for one-third of the total energy consumption in households, and the share of oil in the residential sector's energy consumption is the fourth highest among IEA member countries. Residential oil consumption was substantially higher before the economic crisis. Residential oil consumption dropped by 62% from 2011 to 2014 owing to a combination of increased heating oil prices, reduced household incomes, and the increased penetration of natural gas because of government policy (fuel switching to biomass and natural gas). Consumption increased again in 2015.

Furthermore, Greece has a large share of oil consumed in power generation. Oil power plants generated 11% of the total electricity generation in 2015, which was the highest among all IEA member countries. This is because many of Greece's islands are not yet connected to the mainland electricity grid, but are supplied by isolated systems that rely on diesel generation. Fuel oil is the main oil product used in electricity generation.

Figure 2.4 Oil consumption by sector, 1973-2015



* *Other energy* includes petroleum refineries and energy own use.

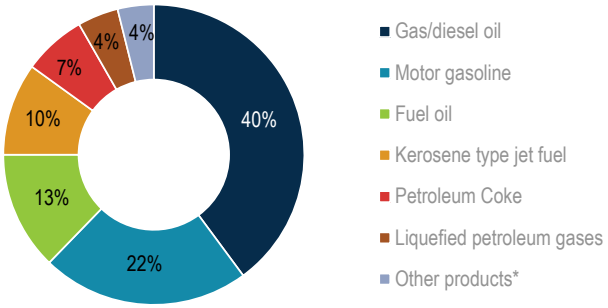
** *Industry* includes non-energy use.

*** *Commercial* includes commercial and public services, agriculture, forestry, and fishing.

Note: Oil in TPES by consuming sector.

Source: IEA (2017a), *World Energy Balances 2017*, www.iea.org/statistics/.

Figure 2.5 Oil consumption by product, 2015



* *Other products* includes bitumen, lubricants, naphtha, and other undefined oil products.
Note: Inland consumption of oil products (in mass units), including oil used in TFC and in energy transformation.
Source: IEA (2017b), *Oil Information 2017*, www.iea.org/statistics/.

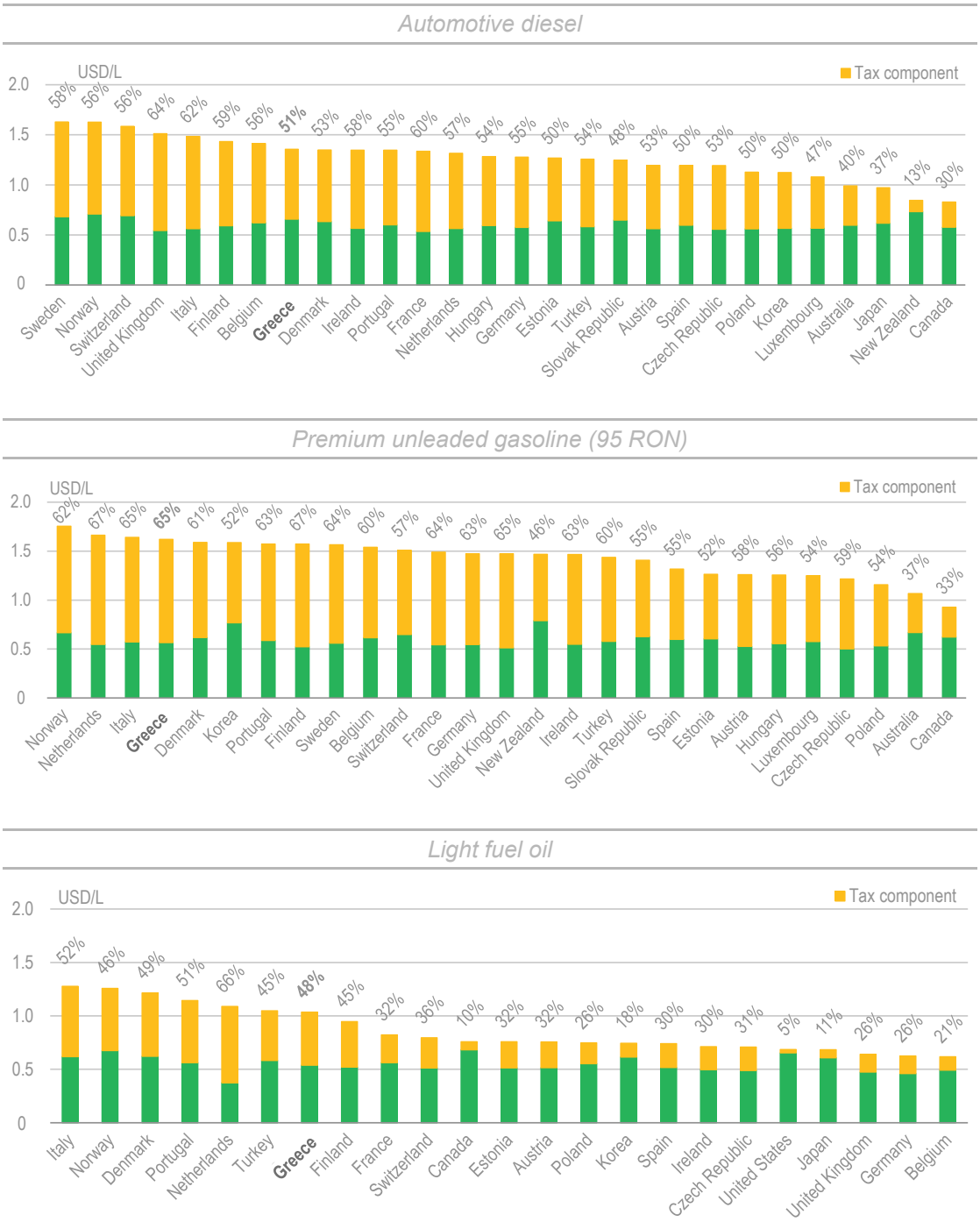
Prices and taxes

In the first quarter of 2017, Greek consumers paid USD 1.36 (United States Dollar) per litre of automotive diesel, over half of which was taxes. This was slightly above average among IEA member countries. Gasoline prices were higher at USD 1.62 per litre, which was the fourth-highest price among IEA member countries. Taxes accounted for almost two-thirds of the gasoline price in Greece. Light fuel oil cost Greek consumers USD 1.04 per litre, around half of which was taxes.

The tax share of the total price has increased for both diesel and gasoline in recent years. Diesel taxes accounted for 48% of the total price and gasoline taxes for 59% in the first quarter of 2011, both below the levels in 2017. Diesel taxes in terms of price per litre decreased by 3%, whereas gasoline taxes increased by 3% from 2011 to 2017. Taxes on fuel oil almost tripled over the same period, and their share of total price for fuel oil increased from 21% in 2011 to 48% in 2017 (see Figure 2.6).

Some 500 000 households receive a subsidy for heating oil that is unrelated to actual consumption but which is determined based on social criteria.

Figure 2.6 Fuel prices in IEA member countries, first quarter of 2017



Note: No data are available for diesel in Japan and fuel oil in Australia, Hungary, New Zealand, Slovak Republic, and Sweden.

Source: IEA (2017c), *Energy Prices and Taxes First Quarter 2017*, www.iea.org/statistics/.

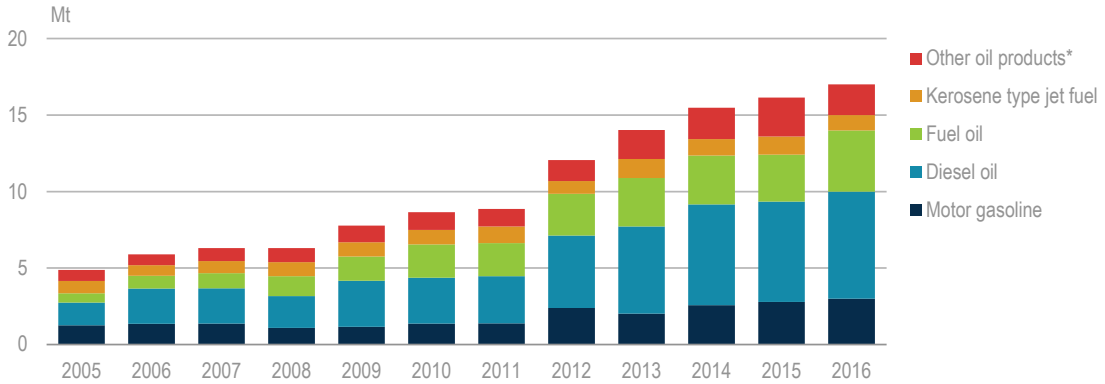
Refining

Imported crude oil is refined in four domestic refineries. The three refineries owned by HELPE, situated in Aspropyrgos, Elefsis, and Thesalloniki, account for about 65% of the total refining capacity. Motor Oil's Agioi Theothoroi refinery near Korinthos produces the remainder. Refinery gross output of oil products was 30.2 Mt in 2016, of which Greece exported a large share because domestic consumption has fallen since 2008. The total net export of oil products was 13.6 Mt, which Greece sold mainly in European markets, but also as far away as Singapore.

Refining output increased significantly by 57% from 2011 to 2016 due to several upgrading and expansion projects (see Figure 2.7). Motor Oil's new crude distillation unit and HELPE's upgrading and optimisation work at the Elefsina refinery resulted in increased production of diesel. The upgrading and expansion also closed the gas/diesel oil deficit in the country. Gas/diesel oil accounted for 41% of the total refinery production in 2016, followed by fuel oil (21%), motor gasoline (19%), and jet kerosene fuel (7%).

Motor Oil's refinery has also acquired the flexibility to process a wide range of crude oil, thereby contributing to import diversification. Moreover, the refinery can now easily switch between producing diesel and gasoline to adapt to seasonal demand patterns in Greece. The upgrading and modernisation work made the refineries among the most profitable in Europe, with modern and environment-friendly specifications. Product exports are dominated by road diesel oil, fuel oil, and motor gas oil.

Figure 2.7 Refined oil product exports, by product, 2005-16



* *Other oil products* includes liquefied petroleum gases, naphtha, lubricants, bitumen, petroleum coke, and other non-specified oil products.

Note: Data are provisional for 2016.

Source: IEA (2017b), *Oil Information 2017*, www.iea.org/statistics/.

The refining sector is a success story of the Greek economy, and the country is one of the key refined product exporters in South Eastern Europe. The refining sector is sensitive to fluctuations in international crude oil and product prices and is operating in a highly competitive global environment largely based in countries with different environmental regulations. Any new obligations levied on the refining sector under the new energy efficiency obligation programme need to be conscious of these constraints.

Infrastructure

Pipelines and other transportation

Greece has two oil pipelines, only one of which is operational. The 53 kilometre (km) Aircraft Fuel Supply Pipeline links HELPE's Aspropyrgos refinery to Athens International Airport at Spata. It is operated by the Athens Airport Fuel Pipeline Company, which also financed and constructed the pipeline. With a capacity of 2.6 million cubic metres (mcm) per annum, it is considered sufficient to accommodate the potential growth of air traffic well into the future.

The second, a 210 km crude oil pipeline, links HELPE's Thessaloniki refinery with its Okta refinery in the Former Yugoslav Republic of Macedonia (FYROM). The pipeline has not been in operation since 2013. The recent change of government in FYROM has raised expectations about reopening the pipeline. Plans to build a pipeline to link Greece with Bulgaria to offer an alternative supply route for Russian and Caspian oil have been discussed for over a decade without much progress. Most crude oil and products are moved by trucks and ships within Greece, while supplies to power plants are transported by train (see Figure 2.8).

Ports

There are ten oil terminals in Greece, with a total loading capacity of 0.8 mcm per day and a total discharging capacity of 2.3 mcm per day. Seven ports are located in the Attica Area (including Athens) and three are in the Thessaloniki area. Six oil terminals (Aspropyrgos, Elefsina, Thessaloniki, Aghioi Theodori, Pachi, and Agia Triada) receive crude oil; four of these are located near the refineries. The country's total crude oil discharging capacity is around 1.6 mcm per day.

Storage

Greece's combined storage capacity was around 10.2 mcm (equivalent to 64 million barrels) in 2015, and was used for industry operations and mandatory industry stocks. This shows that the country has sufficient storage capacity to meet the IEA 90-day obligation, which required Greece to have 3.5 mcm (22 million barrels) of oil storage capacity in 2015.

Market structure

The Greek oil market is principally served by the two refining companies, HELPE and Motor Oil, and their subsidiaries in the wholesale and retail markets. HELPE holds a wholesale market share of about 65%. [5] Over 53 companies operate in Greek's wholesale petroleum sector, holding 80 licences. To stimulate competition and encourage economic growth, Greece has reduced entry barriers into the downstream petroleum market. New laws (4172/2013, 4223/2013, and 4447/2016) have reduced the minimum capital and storage capacity required for applicants for an oil trading licence. In addition, a ministerial decision simplified the licensing procedures for oil retailers in 2016. HELPE and Motor Oil, which operate various brands, dominate the retail market.

[5] https://www.helpe.gr/en/the-group/what-we-do/refining-supply-trading/.

Figure 2.8 Oil infrastructure

This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

HELPE merged its two retail companies (EKO and Hellenic Fuels) in 2016 into one company (EKO Hellenic Fuels and Lubricants Industrial and Commercial), which accounts for over 30% of the market. The retail operations of the merged company continue under the earlier branding logos of EKO and BP. Motor Oil transferred the retail assets of one of its subsidiaries (Cyclon Hellas) to another subsidiary (Arvin Oil) in 2015. The combined retail business accounts for about 12% of the market share. Motor Oil is also the owner of the Shell network, which accounts for about 20% of the retail market and is the leader in automotive gasoline retailing.

The Greek market appears well supplied, with 7 500 retail service stations despite a reduction of about 1 000 stations since 2008 due to the fall in consumption due to the economic crisis. There is, on average, one retail station for about 1 400 inhabitants compared to a European Union (EU) average of 3 800 inhabitants per station (in 2015). This is partly explained by Greece's many islands and the scattered population living in isolated mountainous regions. Retail stations in isolated areas also dispense residential heating oil in small quantities.

Biofuels

Greece is committed to increasing its share of biofuels to 10% of the final energy consumption under Law 3851/2010, which sets the national target for renewable energy sources in compliance with the EU Renewable Energy Directive. Progress made towards this aim is slow (see Chapter 6 on renewable energy), and biodiesel has been used to provide at most 7% of the blend volume since 2009. The blending specification for bioethanol is 10%, but bioethanol is not being used. The government plans to publish an update of Law 3054/2002 in 2017, to promote the penetration of bioethanol as a blending component in gasoline.

Security of supply

Stockholding

The country meets its stockholding obligation to the IEA by placing a minimum stockholding obligation on industry. According to Law 3054/2002 (on organisation of the oil market) and Law 4123/2013 (on maintaining minimum stocks of crude oil and petroleum products), all oil importers and large end users (such as power plants) are required to hold oil stocks equivalent to 90 days of their net imports made during the previous year. Industries are required to hold compulsory stocks in facilities that have been certified as emergency stock storage tanks. Emergency stocks can be held in the same facility as industry stocks; in practice, compulsory stocks are commingled with operational/commercial stocks.

The new legislation also allows the possibility for industries to hold up to 30% of their stockholding obligation in other EU member states under ticket arrangements. However, no such bilateral stockholding agreements have been concluded. The new provision supplements the existing right of entities required to hold compulsory stocks to sign a ticketing contract with a domestic third party. Provided the contract is for a period of at least six months, the third party owns certified emergency storage facilities that are

dedicated exclusively to keeping the emergency oil stocks. The authorisation of the Ministry of Environment and Energy is required for such contracts.

Days cover

Greece has been consistently compliant with the IEA 90-day obligation since the end of 2004. Greece held 35.6 million barrels of oil stocks at the end of March 2017, equating to 145 days of 2016 net imports. Crude oil accounted for 35% of the country's total storage, and Greece held the remainder as products: 24% middle distillates, 12% residual fuel oil, 10% motor gasoline, 6% natural gas liquids and feedstocks, and 13% other products.

Storage capacity

All the storage facilities owned by refineries are certified tanks for emergency stocks. HELPE operates around 70% of the total Greek storage facilities, and it is the country's largest refining company. Part of the storage facilities is used for maintaining stocks for third parties in the context of European Directive 2009/119/EC. Foreign companies with term/spot commercial storage agreements and clients who require oil storage capacity to obtain retailing licences can make use of the available storage capacity.

Drawdown procedures

The Minister for Environment and Energy has the authority to decide on the release of compulsory industry stocks, based on the proposal by the Committee for Management of Severe Supply Disruption of Crude Oil/Petroleum Products. The committee forms the permanent core of the Greek National Emergency Strategy Organisation. The Secretary General for Energy in the Ministry of Environment and Energy chairs the committee, which is composed of 19 members, including the president of the Regulatory Authority for Energy; directors of the ministry; representatives of the ministries of national defence, finance, economy, and transport; representatives from armed forces; and representatives of refineries and retail companies. The committee is supported by permanent and ad hoc working groups such as the International Cooperation Team, Petroleum Prices Analysis Team, Planning Team, Operations Team, Emergency Stocks Team, and Communication.

The cabinet approved the emergency action plan in 2013 for tackling serious oil supply disruptions (Ministerial Cabinet Action 27/2013). The plan includes indicative emergency measures such as release of emergency stocks and demand restraint measures for international and domestic disruptions. The plan facilitates faster decision-making by the committee during a crisis. The government can release compulsory stocks either by lowering industry obligation or by ordering a specific oil company to release a certain amount of emergency oil. Demand restraint measures complement the emergency stock release, where the specific measures and the degree of implementation can be adjusted according to the severity and anticipated duration of a crisis.

In case of IEA collective action, the committee will make a proposal on emergency response measures including how and which type of stocks should be released. The minister is requested to approve (or not) this proposal within 48 hours of the notice of activation under the initial contingency response plan.

Assessment

Oil is the largest source in TPES, accounting for 50%, but Greece has experienced a large reduction in its total oil consumption during the period since the last review, with a decline of 26% between 2010 and 2013. Oil demand has recovered slightly in recent years and reached 11.5 Mtoe in 2016, which was an increase of 11% compared to that in 2013. The transport sector is the main consumer of oil (50%), followed by heat/power generation, industry, and residential, where oil accounted for just over 13% in each sector.

There is a small amount of indigenous oil production in Greece, but most crude oil is imported. Nevertheless, a growing interest in upstream exploration and production offers an opportunity to increase domestic oil production. The government should increase administrative agility and flexibility within the permitting process. Iraq and the Russian Federation were the largest supply sources of crude oil, representing 35% and 24% of the total imports in 2016, respectively. However, the diversified import portfolio over various supply countries looks appropriate to limit the risk of supply disruptions.

Total refinery output in 2016 was 30.2 Mt, with four refineries owned by two different companies. The refineries have invested in complex programmes in recent years and strongly increased their competitiveness. Therefore, during 2011-16, Greece's crude oil imports increased by over half, while net exports of oil products increased by almost sixfold. However, the refining sector is exposed to the international competition of other countries with lower environmental requirements than the EU and is therefore sensitive to any new obligations imposed.

The level of the heating oil subsidy for residential consumers depends on income, the number of people in the household, the value of the home, and the climate zone of the household. The subsidy per winter ranges from EUR 37.5 (Euro) to EUR 625, and is not related to the amount of heating oil consumed. Those households that heat their homes with district heating or natural gas do not receive a subsidy, and there is no incentive for households to switch from heating oil to cheaper fuels such as natural gas.

Recommendation

The government of Greece should:

- ☐ Continue to promote the liberalisation of the impressive competitive refining sector by evaluating the potential impact of national environmental legislation.

References

IEA (International Energy Agency) (2017a), *World Energy Balances 2017*, OECD/IEA, Paris, www.iea.org/statistics/.

IEA (2017b), *Oil Information 2017*, OECD/IEA, Paris, www.iea.org/statistics/.

IEA (2017c), *Energy Prices and Taxes First Quarter 2017*, OECD/IEA, Paris, www.iea.org/statistics/.

3. Natural gas

Key data

(2016 estimated)

Natural gas production: negligible (0.009 bcm)

Net imports: 4.1 bcm, +23% since 2006

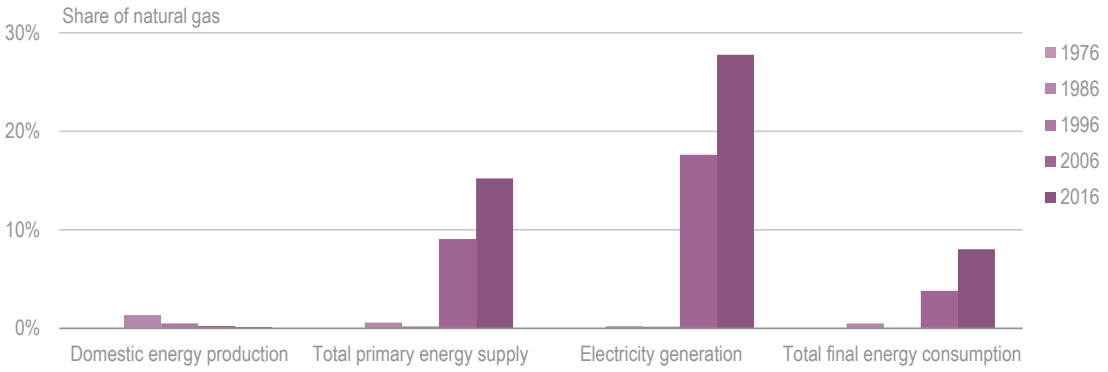
Share of natural gas: 15% of TPES and 28% of electricity generation

Consumption by sector (2015): 2.7 Mtoe (3 bcm) (heat and power generation 49.6%, industry 29.4%, residential 13.4%, commercial and public services, including agriculture and fishing 6.3%, other energy industries 0.8%, transport 0.6%)

Overview

Natural gas is becoming an increasingly important fuel in Greece, rising to a share of 28% in power generation and 15% in the total primary energy supply (TPES) in 2016, and more than doubling its share in total final consumption over the last decade (see Figure 3.1).

Figure 3.1 Natural gas share in energy supplies, 1976-2016



Note: Data are provisional for 2016.

Source: IEA (2017a), *World Energy Balances 2017*, www.iea.org/statistics/.

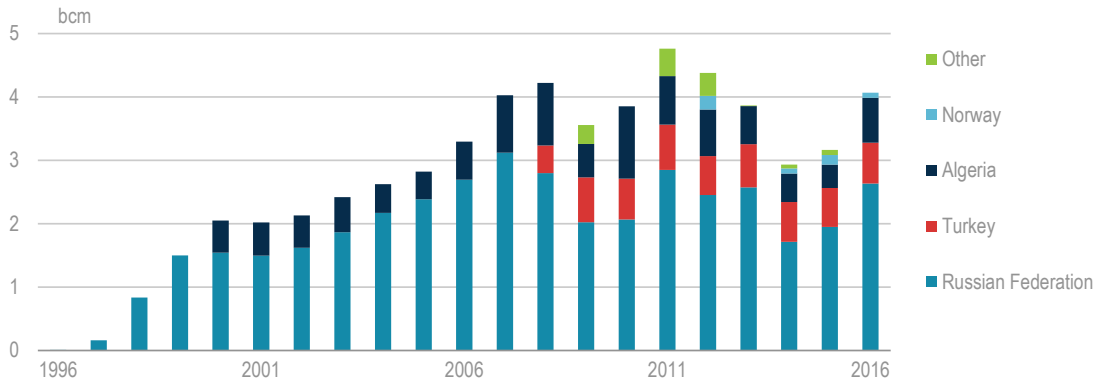
Consumption began increasing in the late 1990s, mainly for power generation and industrial uses, but also later with small shares in the residential and commercial sectors. However, natural gas consumption has fluctuated in recent years, as gas demand decreased with overall energy and electricity demand in the aftermath of the financial crisis, but it has recovered in the last two years. The Greek government has taken several steps towards liberalising and improving efficiency in the gas markets, but work

remains to continue encouraging competition. Most gas is imported from the Russian Federation, and Greece is planning to improve the security of supply through diversification of its supply sources by enhancing liquefied natural gas (LNG) imports and expanding its role as a gas hub for the South Eastern Europe gas market.

Supply and demand

Greece's natural gas production was 0.009 billion cubic metres (bcm) in 2016, which is negligibly small compared to the total consumption of 4.1 bcm. The country is thus dependent on imports, of which the Russian Federation supplied 65% in 2016 (see Figure 3.2). Other large gas suppliers are Algeria, supplying LNG that covered 17% of total gas imports, and Turkey, accounting for 16% of Greece's total imports in 2016.

Figure 3.2 Natural gas imports by country, 1995-2016



Note: Data are provisional for 2016.
Source: IEA (2017b), *Natural Gas Information 2017*, www.iea.org/statistics/.

Natural gas consumption increased rapidly from insignificant levels in 1997 to a peak of 4.0 million tonnes of oil equivalent (Mtoe) in 2011 (see Figure 3.3). After falling by over one-third in three years from 2011 due to the economic crisis, gas consumption recovered to 3.5 Mtoe in 2016 from 2.7 Mtoe in 2015.

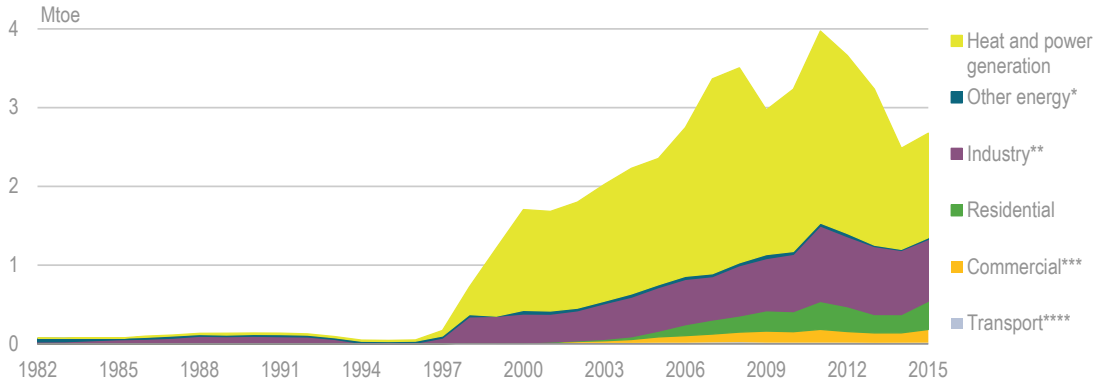
Power generation is the largest gas-consuming sector, accounting for half of the total gas consumption in 2015. This share has fallen from levels of around 70% a decade earlier. The decline in natural gas consumption is mainly due to reduced gas power generation, which fell by over half from a peak at 13.9 terawatt hours (TWh) in 2011 to 6.8 TWh in 2014, but increased to 9.1 TWh in 2015, representing 18% of the total power generation. The fall in total electricity generation (12% from 2011 to 2015) and the growth in renewable energy sources (81% from 2011 to 2015), which have replaced natural gas in the power mix, have resulted in a reduction in gas power generation.

The industry sector is the second-largest consumer of natural gas, accounting for 29% of the total gas demand in 2015. This includes natural gas used as petrochemical feedstock in the chemical and petrochemical industry, which represents almost half of industrial gas consumption. The non-ferrous metals industry (e.g. aluminium) is the largest consumer of natural gas for energy purposes in the industry sector, accounting for nearly one-third of the total gas consumption in industry.

The residential and commercial sectors account for small but growing shares of total gas consumption. Following a drop between 2011 and 2013, gas consumption increased in these sectors to new record levels in 2015, accounting for one-fifth of the total gas consumption. However, natural gas represents only 8% of the total energy consumption in the residential and commercial sectors.

Gas penetration in Greece is following the road network, and about 60% of the network within the geographic area where the distribution companies operate is covered by gas pipelines. Therefore, there is scope for expanding the customer base. Increasing the density of customers on the existing network to better exploit existing infrastructure should be considered as a first step. This would also create the (financial) basis for eventually extending the gas transmission and distribution network into unserved areas.

Figure 3.3 Natural gas consumption by sector, 1982-2015



* *Other energy* includes petroleum refineries and energy own use.

** *Industry* includes non-energy use.

*** *Commercial* includes commercial and public services, agriculture, fishing, and forestry.

**** Negligible.

Notes: Natural gas in TPES by consuming sector. Consumption data per sector are available until 2015. Total gas consumption increased to 3.5 Mtoe in 2016.

Source: IEA (2017a), *World Energy Balances 2017*, www.iea.org/statistics/.

Legal and regulatory framework

The period since 2011 has seen developments in the legal and regulatory framework for the Greek national gas market. Law 4001/2011 prepared the basis for the second round of gas market reforms by transposing the third European Union (EU) Energy Package (Directive 2009/73/EC) into national law. The law stipulated unbundling of the operation of the national natural gas transmission system (NNGTS), giving third-party access to the gas infrastructure, and strengthening the role of the regulator. Laws 4336/2015, 4337/2015, and 4414/2016 amended Law 4001/2011 to reform network undertakings and the full unbundling of the natural gas distribution and retail market in Greece in successive steps by 2018. Greece has progressed towards applying the new laws by issuing and implementing secondary legislation and notifying the required regulations.

The Natural Gas System Network Operation Code of 2010 is being periodically revised in line with requirements for market liberalisation. The 2013 revision provided for the establishment of a fully-fledged entry/exit capacity booking system and the introduction of a virtual nomination point for transactions among all network users.

The third revision of the network operation code became effective in May 2017, to bring the code in line with mandatory EU provisions for balancing network codes and capacity allocation mechanisms. The revised network code incorporates full implementation of an entry/exit system, full renomination rights, acceptance of imbalances in deliveries/off takes in daily nominations, and gradual elimination of user imbalance tolerances. The Regulatory Authority for Energy (RAE) aims for the establishment of a balancing platform and full application of a capacity allocation mechanism at interconnection points towards the end of 2017, with interruptible capacity offered at all points. The implemented provisions of the third revision will enhance the security of gas supply.

Laws 4336/2015 and 4227/2015 provide for the opening of the retail market in successive steps. The full legal and operational unbundling of the integrated supply and distribution companies became effective on 1 January 2017. The final step towards a fully open gas market will be taken on 1 January 2018 when the eligibility of all gas customers to freely choose their suppliers becomes effective.

RAE has regularly updated the tariff regulation. It established a decoupled entry/exit tariff system in 2013, and reviewed the regulation and the tariffs in 2016, which it will implement in 2017. The latest review provides for revision of the capacity and commodity charge, and also for implementation of the capacity allocation mechanism by setting the price methodology for bundled products. RAE also determines tariffs for system services of the transmission system operator (TSO) and the distribution system operators (DSOs).

RAE Decision 589/2016 enacted the distribution network code, which regulates the free access of market stakeholders to the distribution networks. A new licensing regulation and a new supply code are under preparation to complete the regulatory framework of the gas sector.

Market structure and liberalisation

The Public Gas Corporation S.A. (DEPA) still dominates the Greek national gas market, despite over a decade of market reform. The stagnant domestic demand is well supplied until at least 2021 when the first two long-term contracts expire, due to the long-term contracts that DEPA has with Gazprom, Botas, and Sonatrach (for LNG). Consequently, DEPA accounted for 90.4% of the total gas imports in 2016, with only one other LNG importer active since 2012. Additional gas importers have been operating at the interconnection point with Bulgaria since June 2016. DEPA is also the indirect owner of the transmission system and maintains a majority position in the distribution network and the retail sector through its shareholding structure.

Wholesale

Several policy and regulatory initiatives are ongoing to reduce the dominance of DEPA. A gas release programme has been run by DEPA since 2012, to reduce its hold on the wholesale market. This programme is the outcome of a settlement with the Hellenic Competition Commission following a legal case brought against DEPA to enhance competition. The quantity offered as a percentage of the previous year's sales volume is adjusted upward annually to reach 20% by 2021. All quantities have only been made available at the virtual nomination point since the beginning of 2015, thus eliminating the prerequisite of a supply contract between DEPA and the supplier or eligible customer.

Seven network users were active at the interconnection point with Bulgaria at the end of 2016, due to the implementation of the capacity allocation mechanisms at the interconnections.

The Hellenic Gas Transmission System Operator (DESFA) is a legally independent company that operates the NNGTS but remained a 100% subsidiary of DEPA. DESFA is the owner and operator of the national natural gas system (NNGS), which consists of the NNGTS and the LNG terminal on the island of Revithoussa. RAE certified DESFA as the independent transmission operator in 2014, based on a positive opinion from the European Commission. This certification anticipated the ongoing efforts to privatise DESFA and will be transferred to the new owners of the network operator. The privatisation plans for DESFA are part of the government's 2010 economic adjustment programme with international creditors. Greece committed to sell off a 66% stake in DESFA. This effectively moves towards the TSO model where the TSO owns the transmission assets and operates the network, and the gas supply company no longer owns a (decisive) stake in the TSO.

The State Oil Company of Azerbaijan (SOCAR) won the 2013 international competitive tender for a 66% share in DESFA. The European Commission (EC) was required to give its approval for the sale because Azerbaijan is not in the EU. The EC gave approval, provided that SOCAR reduced its stake to 49% by selling 17% to a partner from an EU member state. This partner was Snam of Italy, which also holds a stake in the Trans-Adriatic Pipeline consortium (see the section below). Parties abandoned discussions among SOCAR, Snam, and the Greek Government to finalise the deal in November 2016, as they were unable to reach an agreement about the purchase price.

While the primary driver for DESFA's privatisation was the need to increase revenues for the government under its 2010 deal with creditors, it is also a critical step for the liberalisation of the Greek gas market by breaking DEPA's status as a quasi-vertically integrated monopoly. A new international tender for a 66% share in DESFA was launched in June 2017. Six organisations submitted expressions of interest, including several European TSOs. Two bids were qualified in September 2009 to proceed to the next phase of the tender process. These were a consortium comprising Snam, Enagás Internacional, Fluxys, and N.V. Nederlandse Gasunie; and Regasificadoradel Noroeste of Spain.

Distribution and retail

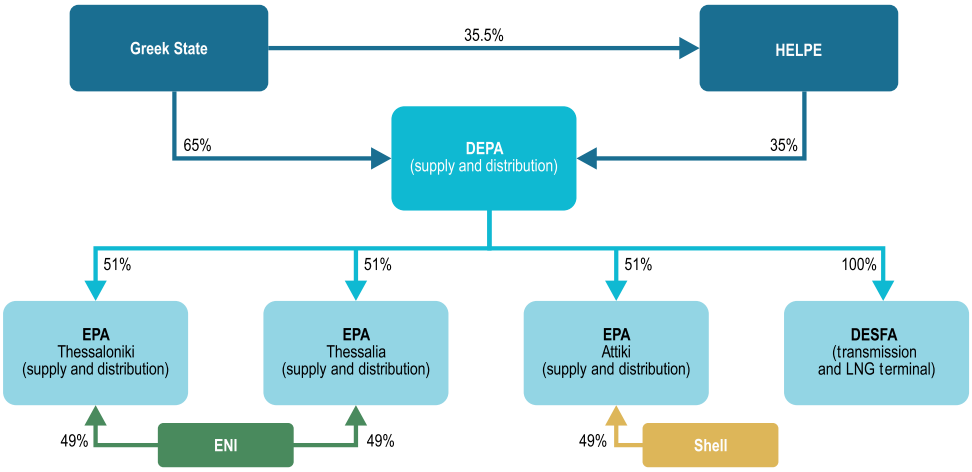
Key provisions of Laws 4336/2015 and 4337/2015 are the opening of supply services to competition and the mandatory unbundling of gas distribution and supply functions in a time-bound manner. Industrial customers became eligible to freely choose their supplier in 2015. The eligibility status for large commercial customers, defined as having consumption larger than 2.2 gigawatt hours over the last 12 months, became effective on 1 January 2017. These two groups together account for 85% of the total demand.

With effect from 1 January 2017, the three existing regional distribution and supply monopoly companies (EPA Attica, EPA Thessaloniki, and EPA Thessalia) completed the legal and functional unbundling of their distribution function from the rest of their activities. The two distribution companies EDA Thessaloniki and EDA Thessalia subsequently merged to create EDA Thess, as they had the same shareholding structure. Similarly,

the two supply companies EPA Thessaloniki and EPA Thessalia merged into one company, EPA Thess.

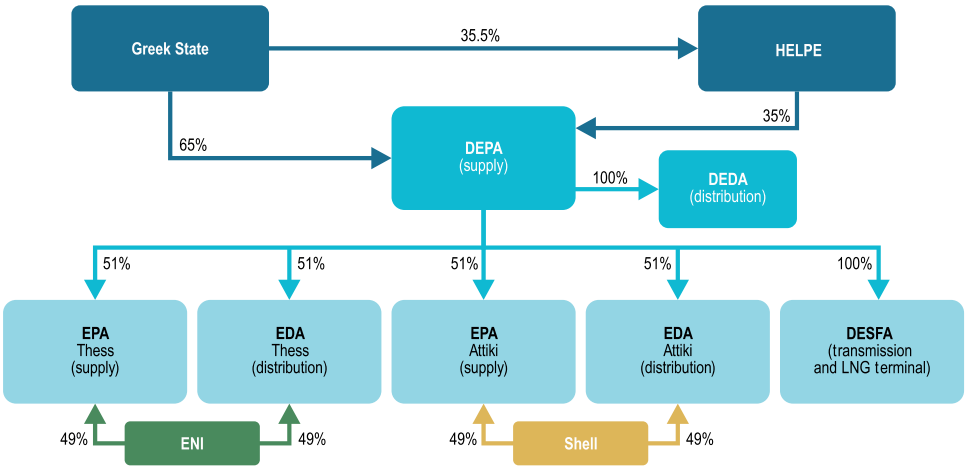
Currently, there are three distribution grid companies: EDA Attikis (Attica area), EDA Thess (Thessaloniki and Thessalia area), and DEDA (a 100% subsidiary of DEPA). DEDA covers the remaining territory of Greece with networks in Sterea Ellada, Central Macedonia, Korinthos, Eastern Macedonia, and Thrace. Each of the three newly created EDAs now holds a distribution licence and a licence to operate the distribution network in their concession area. Ownership of the existing distribution grid remains with DEPA. However, any future new or extended distribution network will be owned by the investors/new distribution companies (see Figures 3.4 and 3.5).

Figure 3.4 Gas market structure before distribution sector unbundling



Source: RAE (2017), "The liberalisation of the gas distribution/retail sector in Greece", Presentation on 5 April 2017, given to IEA team during In-depth review visit.

Figure 3.5 Gas market structure after distribution sector unbundling



Disclaimer: The chart presents the final expected ownership structure after unbundling without including any intermediate transactions between the shareholders and was developed by RAE for presentation purposes only, and therefore should not be treated as reference except to the specific presentation.

Note: EDA Thess covers the same geographical area as EDA Thessaloniki and EDA Thessalia covered earlier.

Source: RAE (2017), "The liberalisation of the gas distribution/retail sector in Greece", Presentation on 5 April 2017, given to IEA team during In-depth review visit.

Under the legal framework, DEPA retains the right to set up new distribution companies in regions beyond the geographical reach of the existing three companies, provided that it also spins off its distribution and supply functions. DEPA's new distribution company, DEDA, and the other two EDAs are now the gas distribution system operators in Greece. DEPA still maintains a 51% majority in the two EDAs, with ENI holding a 49% share of EDA Thess (covering Thessaloniki and Thessalia areas), and Shell having a 49% share in EDA Attikis. The foreign partners are operating the EDAs and the EPAs.

The final step towards full liberalisation of the retail gas market will be taken on 1 January 2018 when all gas customers in Greece will be eligible to freely choose their gas supplier. Consequently, the existing exclusive gas supply agreements with DEPA will be terminated.

Infrastructure

The NNGS comprises the NNGTS, the LNG terminal on the island of Revithoussa, and a compression station at Nea Mesimvria, near Thessaloniki. The transmission system consists of one main, high-pressure pipeline 512 kilometres (km) long and high-pressure line branches that total 975 km in length. There is no strategic gas storage in Greece, and commercial stocks are only held at the site of the LNG terminal. DESFA is the owner and operator of the NNGS.

Table 3.1 Current entry-point capacities to the NNGS

Technical capacity/entry point	Capacity (bcm)
Sidirokastro	3.8
Kipi	1.5
Agia Triada (LNG terminal of Revithoussa)	4.4
Total	**9.7**

Pipelines

The NNGTS has three entry points: two at the north and north-eastern borders (Sidirokastro and Kipi), connecting Greece with the Bulgarian and Turkish gas networks, and one in southern Greece (Agia Triada), linked to the LNG terminal. The total technical capacity of the three entry points is 9.7 bcm per year, calculated on a load factor of 95% (see Table 3.1). The existing capacity is sufficient to cover the forecast demand of 3.8 bcm per year in 2025.

The two pipeline entry points have a total capacity of 5.3 bcm per year estimated on a load factor of 95%. The Greek-Turkish interconnector at Kipi brings gas mainlyfrom the Middle East and the Caspian region into Greece. The interconnector with Bulgaria allows for gas flows from the Russian Federation via Romania, Republic of Moldova, and Ukraine. The interconnector with Bulgaria has been able to operate a reverse flow of 0.3 bcm per year since May 2014, thus enhancing the security of supply.

LNG

The biggest natural gas infrastructure of Greece is the LNG terminal on Revithoussa Island. It plays a key role in the operation of the NNGS, especially during security of supply crises. The terminal has a capacity of 4.4 bcm per year calculated on a load factor of 95%, and is also the only gas storage site in Greece with a capacity of 130 000 cubic metres (m^3). The sustained maximum send-out rate is 1 m^3 of LNG per hour, which can increase to 1 250 m^3 per hour, equivalent to 12.47 million cubic metres (mcm) per day, when back-up gasifiers are used.

Extension work on the Revithoussa terminal is ongoing. Upon completion, the terminal will be able to receive larger ships with a capacity of up to 260 000 m^3, the gasification rate of the terminal will be increased by 40%, and the metering station will be upgraded accordingly. A third tank with a capacity of 95 000 m^3 of LNG, equivalent to 54 mcm of natural gas, is expected to come into operation in May 2018 (see Figure 3.6).

Private company Gastrade, S.A. has plans for the construction of an LNG floating storage and regasification unit (FSRU) in Alexandroupolis (eastern Greece), which could supply 6.1 bcm per year with a send-out capacity of 700 000 m^3 per hour. The FSRU would be connected by a submarine and onshore pipelines to the NNGS. It would have a storage capacity of 170 000 m^3 of LNG (or 97 mcm of natural gas). The EC awarded it a project of common interest (PCI) status in 2013, the licensing process is complete, and the final investment decision is expected in 2018, with commercial operation set to start at the end of 2019.

Storage

The country's only gas storage facility is located at the LNG terminal on Revithoussa Island. The island has two LNG tanks with a combined capacity of 130 000 m^3, equivalent to 74 mcm of natural gas. This equates to 3.1 days of peak demand (23.59 mcm per day observed in 2017).

Greece has no underground gas storage facilities. However, it is exploring options to convert the depleted South Kavala gas field into one. South Kavala is nearing the end of its lifespan, with the licence issued to Energean set to expire in late 2017. The proposed storage facility would have a capacity of 360 mcm (approximately 14.8 days of peak demand), an injection rate of 5 mcm per day, and a withdrawal rate of 4 mcm per day. The facility could become a key contributor to supply security in Greece, helping to deal with the expected increase in demand from the residential and electricity sectors as well as enhancing regional connectivity. The facility would strengthen the peak shaving capacity and also the country's resilience against major natural gas disruptions. The EC included the project in the temporary PCI list in June 2017, and Greece is confident that the project will be retained in the final list, which is expected to be announced in late 2017.

The expansion of the Revithoussa Island LNG facility and conversion of the South Kavala depleted gas field would increase the total Greek storage capacity to 477 mcm, equating to 20.2 days of peak demand.

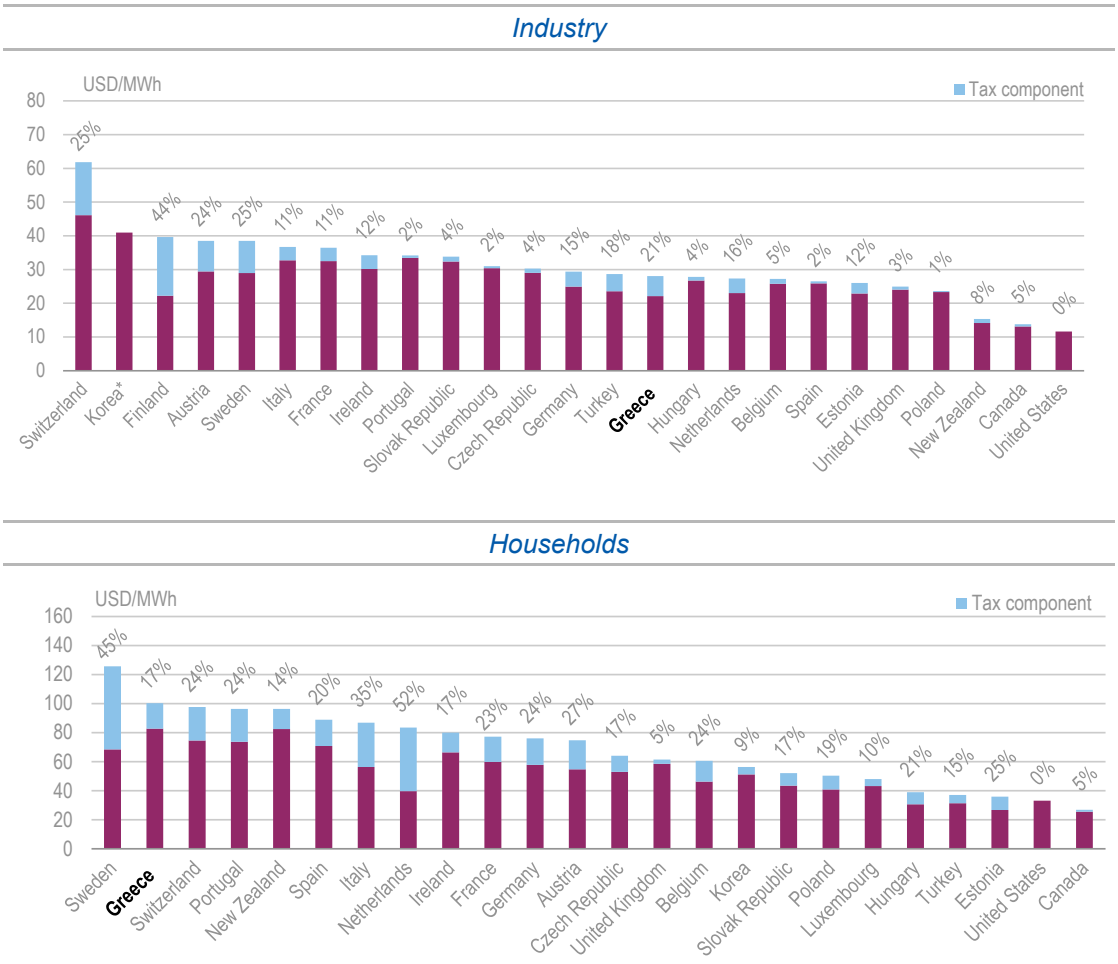
Figure 3.6 Natural gas infrastructure

This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Taxes and prices

Greece's households paid USD 100 per megawatt hour (MWh) for natural gas in 2016, which was the second-highest price among IEA member countries, after Sweden (see Figure 3.7). Excluding taxes, Greek retail household prices were the highest among IEA member countries. The industry sector pays significantly lower prices for natural gas. Greece's industry price was USD 28 per MWh in 2016, which was slightly lower than the median price paid by industries in other IEA countries. Natural gas prices increased significantly in the early 2000s and after the 2009 drop in the aftermath of the global financial crisis. However, in recent years, natural gas prices have fallen in most IEA countries, both for households and for industries. Compared to other southern European countries, Greece's natural gas prices increased more until 2012/13, but have since fallen more rapidly (see Figure 3.8). Industry prices are similar among Greece and peer countries, whereas household prices show a wider spread.

Figure 3.7 Natural gas prices in IEA member countries, 2016

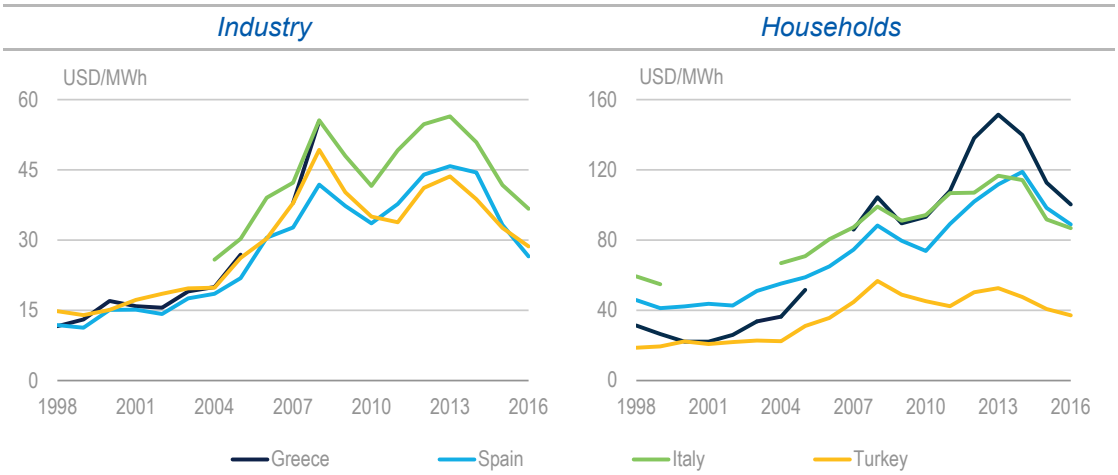


* Tax information is not available.

Note: Data are not available for Australia, Japan, Norway, Denmark (industry and households), and Finland (households).

Source: IEA (2017c), *Energy Prices and Taxes 2017*, www.iea.org/statistics/.

Figure 3.8 Natural gas prices in selected IEA member countries, 1998-2016



Note: Data are not available for Greece for 2006 and Italy for 1999-2003.

Source: IEA (2017c), *Energy Prices and Taxes 2017*, www.iea.org/statistics/.

Security of supply

Existing gas infrastructure does not meet the N-1 standard.[6] Greece has a tight capacity margin, notably during winter peak demand, and relies mainly on its Revithoussa LNG terminal for flexibility, which is also the single-largest gas infrastructure with the highest supply capacity. Greece relies on demand-response policies and fuel-switching measures until the additional infrastructure under construction and consideration becomes available. These measures combined can reach a total reduction of approximately 3 mcm per day.

Assuming a combined technical capacity of entry points of 15.1 mcm per day (10.8 mcm per day at Sidirokastro and 4.3 mcm per day at Kipi), maximum peak demand of 23.59 mcm per day (observed in 2017), and a potential for demand-side reduction of 3.07 (administration estimates), gives an N-1 value of 73.6%. Greece has no strategic gas storage.

Emergency policy, legal, and regulatory framework

DESFA is responsible for declaring an emergency gas situation and carrying out an emergency response plan, under the network code of 2010. DESFA established such a plan in 2013 and revised it in 2015. The plan lays out the allocation of responsibility of the crisis management bodies, sets procedures for responding to an emergency, and lists measures that may be implemented during each of three crisis levels: 1) early warning, 2) alert, and 3) emergency, as defined in EU Regulation No. 994/2010. Key revisions to the emergency plan relate to the signing of contracts for demand reduction, fuel switching, and interruptible customers. The revised emergency response plan also reflects RAE Decision 344(2014) on the creation of a security of supply account and levy. The levy is set by RAE, and the special account is administered by DESFA.

[6] The N-1 formula describes the ability of the technical capacity of the gas infrastructure to satisfy total gas demand in the event of disruption of the single-largest gas infrastructure during a day of exceptionally high gas demand.

Supply-side measures

Greece is pursuing projects to enhance the security of gas supply. One such project is the construction of a third LNG tank (capacity 95 000 m^3) at the Revithoussa terminal, which is in progress. The total storage capacity at the facility will be 225 000 m^3 of LNG, or 127 mcm of natural gas, once this third tank is operational. This equates to approximately 5.4 days of peak gas demand.

Greece is also involved in several international gas pipeline projects to diversify supply options to enhance supply security, and with a view to establishing the country as a gas hub in South Eastern Europe. Some of the pipelines are detailed below.

Trans-Adriatic Pipeline

The 10 bcm Trans-Adriatic Pipeline project will bring gas from the Caspian region to Europe via Turkey, Greece, and Albania, with an end point in Italy. The Greek portion of the pipeline will cover 550 km and connect to Turkey at Kiproi and to Albania at Ieropigi.

The EU granted the project an exemption from third-party access, regulated tariffs, and ownership unbundling for a period of 25 years in 2013. Construction of the pipeline is ongoing, and commercial operations are scheduled to begin in 2020.

Interconnector Turkey-Greece-Italy

The Interconnector Turkey-Greece-Italy project is designed to transfer natural gas from the Caspian region (Azeri gas from Shah Deniz II). It consists of three distinct parts: 1) the 296-km Interconnector Turkey-Greece, which has been in operation since 2007; 2) a 570-km onshore pipeline from Komotini to Igoumenitsa on the north-western coast; and 3) a 216-km offshore Poseidon pipeline from Thesprotia to Italy.

DESFA would construct the onshore pipeline as part of the Greek NNGS. The offshore pipeline would be built by IGI Poseidon, a joint venture of Italy's Edison (50%) and DEPA (50%). The EC confirmed the Poseidon pipeline as having PCI status in 2015, and granted the offshore interconnection a 25-year exemption from third-party access for 8 bcm per year.

Interconnector Greece-Bulgaria Pipeline

The Interconnector Greece-Bulgaria Pipeline is critically important for enhancing the security of supply in South Eastern Europe by connecting the Greek and Bulgarian networks and allowing imports from multiple sources. It will be designed to allow physical and commercial reverse flow, and will connect with DESFA and Trans-Adriatic Pipeline systems near Komotini in north-eastern Greece. From there, it will span 160 km to connect to the Bulgarian gas system in Stara Zagora.

The EC certified the pipeline as a PCI in 2015, and also identified it as a priority under the EU Central and South Eastern European Gas Connectivity Initiative. The final investment decision was taken in December 2015, and construction is scheduled to start in early 2018. A joint venture of IGI Poseidon and state-owned Bulgarian Energy Holding is promoting the project.

EastMed Pipeline

The EastMed Pipeline is an offshore/onshore pipeline project by IGI Poseidon SA that would be approximately 1 900 km long, directly connecting Eastern Mediterranean gas reserves to Greece. The EC includes the project in its current list of PCIs. The estimated

overall investment cost is EUR 5.2 billion (EUR 6.2 billion including an extension to Italy), based on a detailed feasibility study. The pipeline would initially transport 10 bcm per year in its current design.

The strong international interest in the pipeline projects is a reassuring sign for the potential of the Greek energy market to transform into a regional gas hub for South Eastern Europe. The increased capacity, including for reverse flow, would enhance the diversification and flexibility of gas supply. The related investments would be a substantial boost for the Greek economy and would promote employment. The pipelines would also allow for eventually expanding the Greek domestic gas network into unserved areas in a cost-effective manner. However, thorough commercial and economic viability assessments of the proposed international pipeline projects are required to ensure that there is no over-capacity being built, to the detriment of consumer interests. Greece should also consider taking a proactive leading role in coordinating planning, trading policies, and regulations of the concerned national markets, to establish a common regulatory framework required for a gas hub.

Demand-side measures

Greece has operationalised three demand-side measures: voluntary demand reduction, fuel switching, and interruptible contracts.

Voluntary demand reduction

Greece has implemented an incentive programme to encourage gas consumers to undertake voluntary measures to reduce demand during crisis situations. Large consumers are compensated for voluntary demand reduction during gas disruptions at alert and emergency levels. The compensation is funded through a security of supply levy that is set by RAE (Decision 344/2014) and paid by all gas consumers. DESFA manages the security of supply levy account. The users are mainly gas-fired power plants, but a few large industrial units have also recently been included under the programme. RAE approved the templates for contracts for the gas supplier (DESFA) and the demand-reducing entity in 2016 (628/2016). In addition, gas suppliers have the possibility to sign contracts with DESFA to be reimbursed in part or total for the costs they incurred due to the implementation of demand-side measures. This programme could lead to savings of approximately 1.5 mcm per day.

Fuel switching

Fuel switching is a primary tool by which Greece could respond to a disruption of natural gas supplies. The capacity to switch from natural gas to alternative fuels (oil) is concentrated at gas-fired power plants, because all new gas-fired power producers are obliged to hold at least five days' worth of back-up reserves of dual fuel (mainly diesel oil), so that they can be granted an electricity production licence. These plants sign contracts with DESFA to ensure their capacity to switch during a gas supply crisis. Greece has 13 gas-fired plants, with a combined generation capacity of 4 970 megawatts (MW). Five of those, with a combined generation capacity of 1 760 MW, have the capacity to switch from natural gas to oil during a gas disruption.

Assuming the share of natural gas consumption among these plants is consistent with their share of generation capacity (i.e. 35%), and given that natural gas consumption among these plants was approximately 1.6 bcm for 2015, switching away from natural gas in these plants could save approximately 552 mcm per year or 1.5 mcm per day,

based on average daily generation. Some large industrial consumers are also capable of switching from natural gas to oil in the event of a supply disruption. The fuel-switching capacity of gas-fired power plants and large industrial consumers is approximately 3 mcm per day. This equates to approximately 35% of the average daily demand (8.6 mcm per day) or approximately 13% of the daily peak demand (23.59 mcm per day, observed in 2017).

Box 3.1 Greece's winter supply crisis in 2016/17

The country's gas emergency response plan proved robust during the gas supply crisis in the winter of 2016/17. Two unforeseen events coincided in early December: gas demand increased on seven successive days, and bad weather at the loading point delayed the expected LNG delivery from Algeria. These resulted in Greece calling an alert (level 2 out of three levels) on 21 December 2016. Greece reduced the crisis level to early warning (level 1) when the LNG cargo eventually arrived, although the exceptionally high gas demand continued. Greece chronicled a record gas demand of 277 000 MWh on 12 January 2017, while bad weather again delayed the next LNG delivery. Greece raised the emergency level to alert again until 13 February. Gas demand in the period 1 December 2016 to 28 February 2017 was 47% higher than that in the same period of the previous year.

Greece employed all measures of the gas emergency plan to handle the crisis. Imports at the entry point of Kipi spiked during the alert level, additional LNG cargoes were received, and the LNG storage facilities were heavily drawn upon in the period between tanker discharges. Greece also executed demand-side measures, with 10% of the estimated demand reduced during the December alert and 6% of the demand reduced during the January-February alert level. Greece is commended for managing the gas crisis in a comprehensive and reassuring manner.

This winter gas crisis underlined that Greece remains vulnerable to the failure of its largest gas infrastructure, through delays in LNG deliveries, or unexpected shortages of gas supply at the interconnection points. Therefore, Greece has an urgent need to complete additional LNG storage facilities to provide the necessary gas system margin to deal with unexpected high demand. Peak demand during the winter of the 2016/2017 gas crisis reached 23.59 mcm per day, and storage coverage was reduced to barely three days of demand.

One of the lessons learned from the crisis is the strong interaction with the electricity supply during a gas crisis. Greece must allow the electricity and gas markets to react to price signals to avoid the creation of a price imbalance that encourages electricity exports to neighbouring countries. Export of electricity is an attractive proposition for power producers in Greece, as they can obtain high payments for their electricity in other countries while their gas input price does not increase much. This is despite the shortage in the Greek gas market. The lessons learned will need to be reviewed for the next update of the gas emergency plan and should also feed a deeper analysis by all policy actors about the functioning of the electricity and gas markets in Greece.

Interruptible customers

RAE, under its Decision 344/2014 and as included in the emergency plan revision of 2015, has specified a category of interruptible customers. These are customers other than power producers or protected customers who will be expected to reduce their demand by at least 40% within six hours of receiving notice from their suppliers. Customers declared interruptible are not required to pay the security of supply levy but are charged a penalty of 200% of the levy if they do not meet their obligations during a gas emergency crisis.

Assessment

Greece has made important progress in the liberalisation of the gas markets, among others through the introduction of a gas release programme. A step to liberalise the retail markets is at an advanced stage of implementation, promising a more-competitive environment and renewed impetus to the penetration of gas as a fuel.

The Greek authorities are commended for the efforts already made, which have been an important step towards the emergence of gas markets and which will eventually produce market outcomes attractive to end customers and investors alike, and allow for a transition to a greener environment. Greece needs to ensure these reforms will be implemented.

The state remains in control of most of the gas supply through DEPA, including balancing requirements. According to current estimates, DEPA contracts will be sufficient to meet gas demand until 2021. DEPA is also the owner of DESFA. The unbundling of the previously existing EPAs has created separate distribution companies, now properly incentivised to intensify the usage of the existing infrastructure and ensure its further roll-out. Greece has also created separate supply companies to supply gas and to bundle energy offers and energy services to consumers in competition with other suppliers. This has the potential to bring welcome competitive pressure and innovative business models to the Greek energy markets. The current position of DEPA in the two EPAs should be evaluated with a view to increasing competition and eliminating any potential conflicts of interest among the different commercial interests of DEPA along the gas value chain, which could potentially result in suboptimal outcomes for consumers.

There are three distribution areas with a revenue incentive set by RAE to increase the consumption rate of gas where the infrastructure is already available. This will allow greater use of natural gas in the residential sector and reduction of inefficient and old heating systems, while minimising network investment costs.

Greece is to be congratulated for the following regulatory improvements that have been put in place in recent years: 1) procedures for third-party access in the transmission system, interconnections, and LNG facilities; 2) legal and operational unbundling within the three main distribution and supply companies; 3) full liberalisation of the gas market from January 2018 (all consumers, including households, will be able to choose their gas supplier); 4) determination by the regulator of tariffs for system services of the TSO (and DSOs); 5) implementation of the capacity allocation mechanisms EU network code in the interconnections, which allowed having seven importers to be active at the interconnection point with Bulgaria at the end of 2016; and 6) reduction of DEPA's dominance in the gas sector, where the public corporation is obliged to run gas release programmes annually.

All of these regulatory efforts will promote change within the industry structure. However, Greece should continue encouraging competition and opening the natural gas market to new entrants. The privatisation process and new shareholding programme of DESFA should be completed. The next step is to develop a trading platform, implementing the EU balance network code that will reflect a transparent, liquid, and reliable wholesale market, which will also enhance the security of gas supply.

Greece intends to play an important role in the natural gas market in South Eastern Europe. The process of diversifying supply sources and expanding Greece's role as a transit country includes the operation of the Trans-Adriatic Pipeline by the end of the year 2020, upgrading the Revithoussa LNG capacity, and promoting the construction of additional facilities. A robust cost-benefit analysis of gas infrastructure expansion should be carried out within the DESFA Ten Years National Development Plan, due to the financial difficulties and without a forecast of internal gas demand growth.

To create a South Eastern Europe gas hub is a challenge that could improve the EU security of gas supply and diversify its supply portfolio. There are many overlapping energy transit projects in the area, and co-ordination among all the countries in South Eastern Europe is needed. Greece can play an important role by leading reforms in order to share the same regulatory framework.

Recommendations

The government of Greece should:

- Continue to stimulate competition in the gas market, by allowing new entrants and thus reducing the dominant share of DEPA, and develop a liquid wholesale market that will reflect a transparent and representative price of gas at the virtual trading point.
- Guarantee the independence and efficiency of the gas TSO by ensuring that, post privatisation, it is operated as an ownership unbundled TSO with shareholders that possess significant and relevant TSO knowledge.
- Take steps to eliminate remaining obstacles, including in the recently unbundled gas supply companies, to ensure that the potential benefits of the otherwise commendable steps to liberalise the gas retail markets can be realised in full and benefit Greek consumers.
- Continue to enhance the security of supply by adding flexibility to the NNGS in case of a crisis and facilitating investments in new infrastructures and interconnections.
- Carefully assess planned gas infrastructure projects based on cost-benefit analysis with a view to prioritising areas where they can provide the largest contribution to the gas security of the country and the region.
- Co-ordinate gas trading policies and regulations within South Eastern Europe so that Greece can become a South Eastern Europe gas hub.

References

IEA (International Energy Agency) (2017a), *World Energy Balances 2017*, OECD/IEA, Paris, www.iea.org/statistics/.

IEA (2017b), *Natural Gas Information 2017*, OECD/IEA, Paris, www.iea.org/statistics/.

IEA (2017c), *Energy Prices and Taxes 2017*, OECD/IEA, Paris, www.iea.org/statistics/.

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4. Electricity

Key data

(2015/16)

Total electricity generation (2016): 48.8 TWh, -18.9% since 2006; net import 8.8 TWh

Electricity generation mix (2016): coal 31.6%, natural gas 27.8%, hydro 11.4%, oil 9.9%, wind 10.5%, solar 8.1%, biofuels and waste 0.7%

Installed capacity (2015): 18 942 MW

Peak load (2015): 9 195 MW

Electricity consumption (2015): 52.4 TWh (commercial 38.5%, residential 33.4%, industry 24.2%, other energy 3.2%, transport 0.7%)

Overview

Electricity demand (in terms of production plus net imports) decreased by 16% from 2008 to 2016 due to the economic crisis. Coal/lignite[7] is the dominant fuel in the generation mix, followed by gas and renewable energy sources (solar and wind). The largest electricity consuming sector is the commercial sector, followed by the residential sector. Greece has taken several steps towards liberalising and deregulating the wholesale and retail power markets to increase competition. Greece will be transitioning to the new European Union (EU) target market, with forward, day-ahead, intraday, and balancing markets. Greece has made substantial progress in diversifying the electricity fuel mix, especially in the deployment of variable renewable energy, which increased to almost 19% of the total generation in 2016.

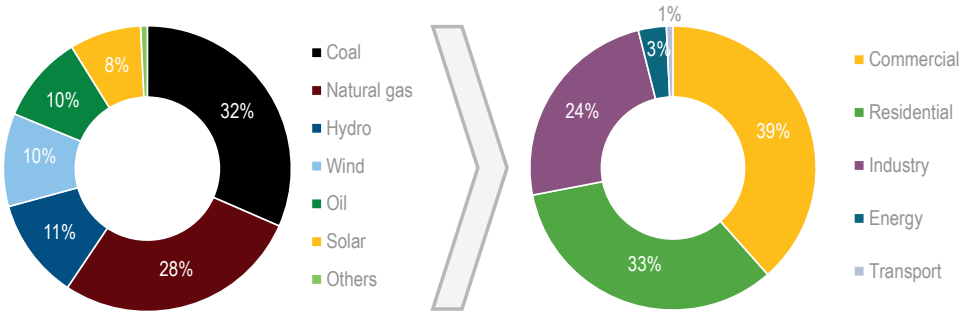
Greece has a large potential to grow the shares of clean power once its non-interconnected islands (NIIs) become integrated into the mainland electricity system. The anticipated reduction in the share of lignite production to comply with environmental policies raises concerns about supply adequacy that will need addressing when progressing with power sector reforms.

[7] Lignite is the dominant fuel for electricity production in Greece. The terms lignite and coal are used interchangeably in this report.

Supply and demand

Fossil fuels have historically played an important role in Greek power generation, and accounted for almost 70% of the total electricity generated in 2016. However, their dominance has decreased over the past decade, due to a fall in electricity consumption and a growth in renewable generation by wind and solar. Renewable energy sources accounted for nearly one-third of the total electricity generation in 2016 (see Figure 4.1). Electricity consumption decreased due to the economic recession and has not fully recovered.

Figure 4.1 Electricity generation by source, and consumption by sector, 2015/16



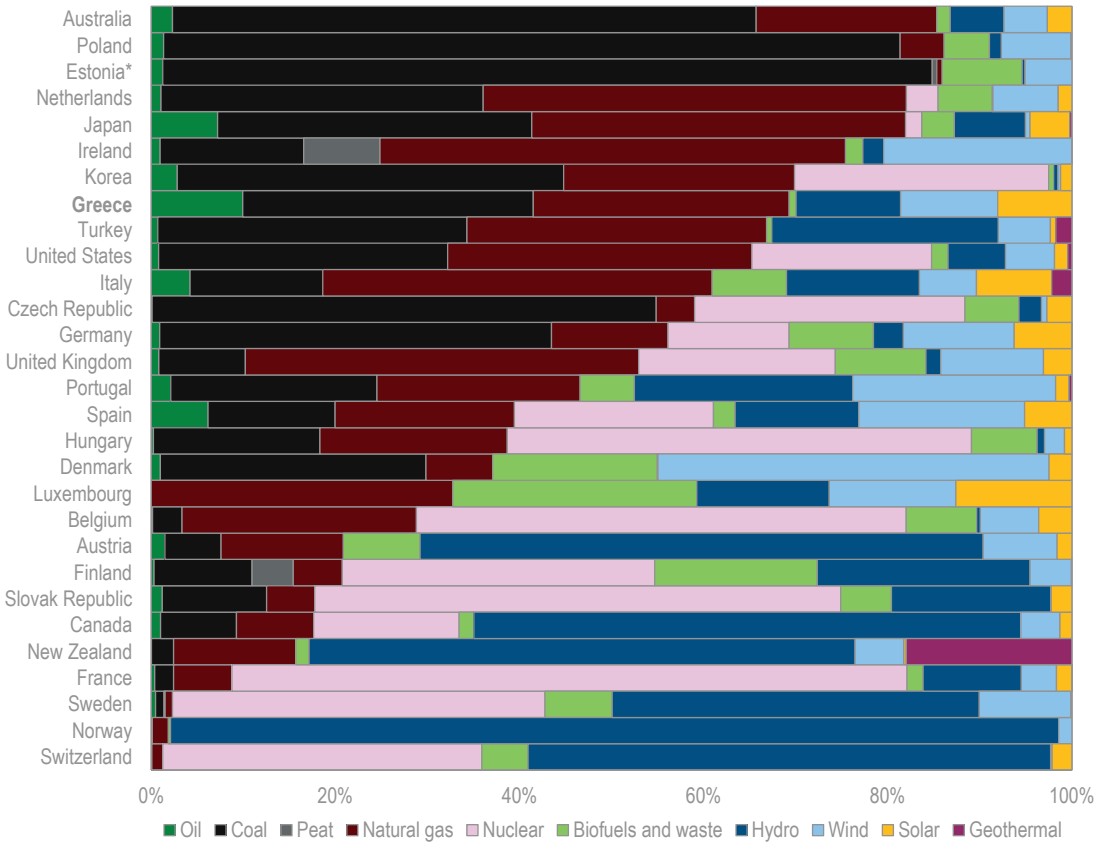
Note: Supply data are 2016 estimates, consumption data are for 2015.
Source: IEA (2017a), *Electricity Information 2017*, www.iea.org/statistics/.

Production

Greece generated 48.8 terawatt hours (TWh) of electricity in 2016, a decrease of 19% since 2006. Coal is the largest energy source, accounting for 31.6% in 2016, followed by natural gas at 27.8%. Greece had the eighth-highest share of fossil fuels in electricity generation among IEA member countries in 2016, and the highest share of oil (see Figure 4.2). Coal is the largest power source in terms of installed capacity, followed by natural gas (see Table 4.1).

However, the dominance of fossil fuels has decreased in the past decade. While electricity generation from coal and oil decreased by around 50% each between 2006 and 2016, power generated from renewable sources almost doubled over the same period (see Figure 4.3). Hydro was the third-largest energy source in electricity generation in 2016, but the main growth in renewables has come from wind and solar power. The share of wind power increased from 2.8% in 2006 to 10.5% in 2016, and solar power grew even more rapidly, from 0.3% in 2010 to 8.1% in 2016.

Figure 4.2 Electricity generation by source in IEA member countries, 2016

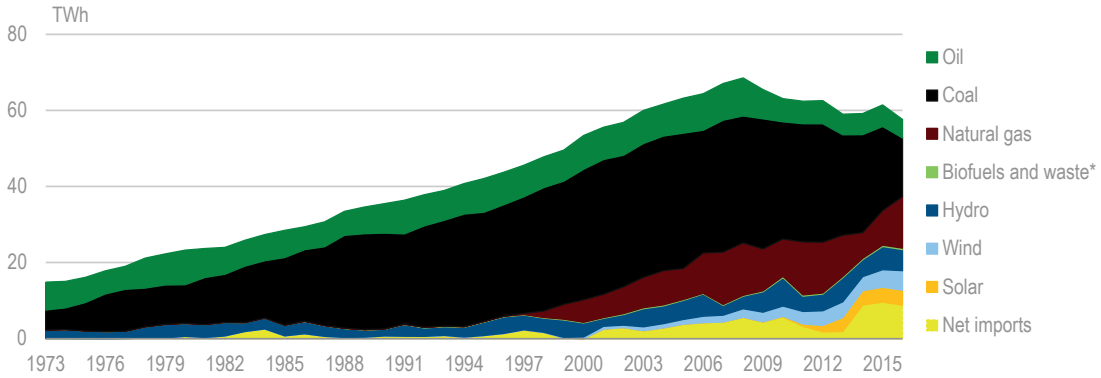


* Estonia's coal consumption is represented by oil shale.

Note: Data are provisional for 2016.

Source: IEA (2017b), *World Energy Balances 2017*, www.iea.org/statistics/.

Figure 4.3 Electricity generation by source, 1973-2016



* Negligible.

Note: Data are provisional for 2016.

Source: IEA (2017b), *World Energy Balances 2017*, www.iea.org/statistics/.

Table 4.1 Installed electricity generating capacity by source, 2000-15 (MW)

Energy source	2000	2005	2010	2011	2012	2013	2014	2015
Combustible fuels	7 606	9 708	10 597	11 048	11 226	11 229	10 932	10 855
Coal and coal products	4 492	4 808	4 793	4 793	4 556	4 556	4 302	4 302
Natural gas and gas works gas	1 112	2 529	3 252	3 677	4 117	4 103	4 068	3 972
Liquid fuels, including refinery gas	1 966	2 318	2 505	2 505	2 503	2 500	2 492	2 503
Other combustible fuels	36	53	47	73	50	70	70	78
Hydro	3 072	3 106	3 215	3 224	3 236	3 238	3 389	3 392
Wind	226	491	1 298	1 640	1 753	1 809	1 978	2 091
Solar photovoltaics	0	0	1	202	612	1 536	2 579	2 596
Total capacity	**10 904**	**13 306**	**15 312**	**16 524**	**17 751**	**18 855**	**18 895**	**18 942**

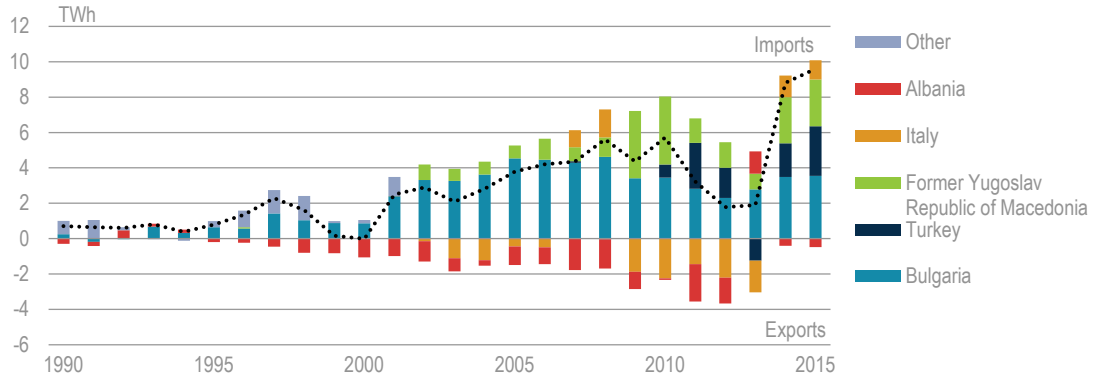
Source: IEA (2017a), *Electricity Information 2017*, www.iea.org/statistics/.

Note: MW = megawatts.

Imports and exports

Greece is well connected with neighbouring countries and, in addition to domestic power generation, Greece is becoming increasingly active in electricity trade. Electricity imports have increased with new interconnections, although these have large annual variations (see Figure 4.4). Greece's net electricity imports in 2015 were 9.6 TWh, mainly from Bulgaria (32% of total imports), Turkey (25%), Former Yugoslav Republic of Macedonia (FYROM) (25%), and Italy (15%). Greece has been a net importer for many years, but also occasionally exports, mainly to Italy and Turkey. Total net imports were 8.8 TWh in 2016.

Figure 4.4 Electricity imports and exports by source, 1990-2015



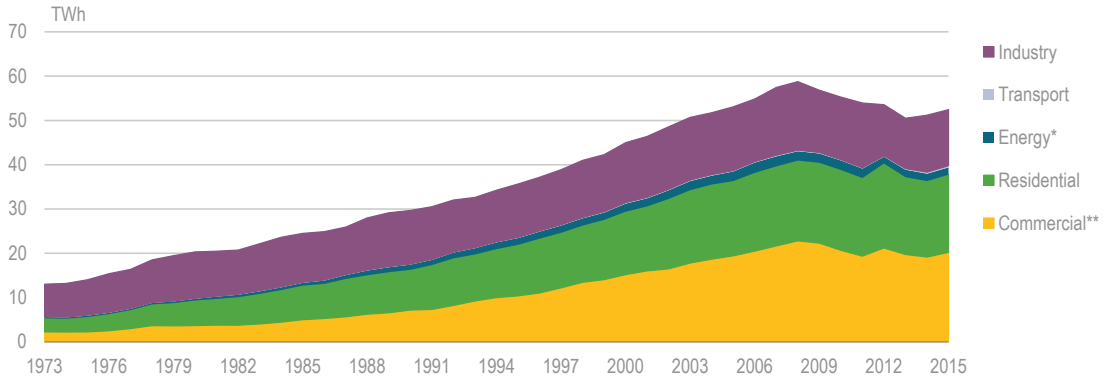
Source: IEA (2017a), *Electricity Information 2017*, www.iea.org/statistics/.

Consumption

Greece's electricity consumption increased steadily until it reached a peak of 58.8 TWh in 2008, followed by a five-year period of decline from 2009 to 2013 in the aftermath of the economic crisis. Consumption has recovered slightly in recent years, and in 2015, Greece consumed 52.4 TWh of electricity.

The commercial sector was the largest electricity consuming sector, accounting for 38% of the total consumption in 2015 (see Figure 4.5). It was followed by the residential sector (33.4%) and industry (24.2%). Other sectors (i.e. other energy industries and transport) accounted for only a small share of the total electricity consumption.

Figure 4.5 Electricity consumption by sector, 1973-2015



* *Energy* includes coal mines, petroleum refineries, and oil and gas extraction.

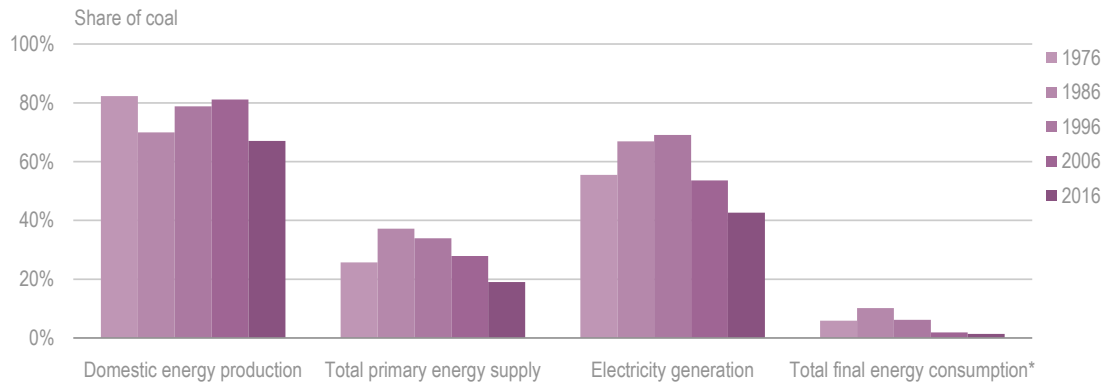
** *Commercial* includes commercial services, agriculture, forestry, and fishing.

Source: IEA (2017a), *Electricity Information 2017*, www.iea.org/statistics/.

Role of coal in power generation

Lignite is a significant domestic fossil fuel resource in Greece, and is an important component of Greece's energy security. Greece is the fourth-largest lignite producer in the European IEA member countries (behind Germany, Poland, and Czech Republic) with a total production of 32.3 million tonnes in 2016. Coal is the second-largest fuel in the total primary energy supply after oil, but accounted for only a small share of the total final consumption from industry consumption (see Figure 4.6).

Figure 4.6 Coal share in energy supplies, 1976-2016



* The latest consumption data are from 2015.

Note: Data are provisional for 2016.

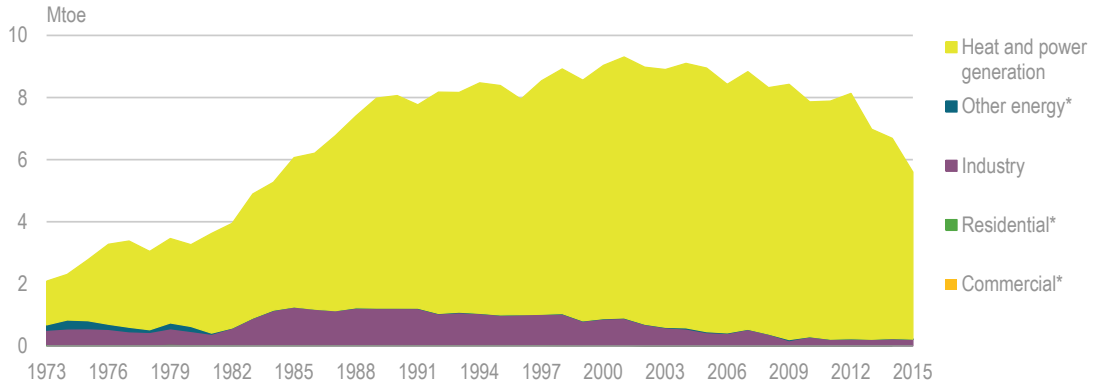
Source: IEA (2017b), *World Energy Balances 2017*, www.iea.org/statistics/.

Most of the coal is used in the power sector, accounting for 43% of consumption (see Figure 4.7). Electricity generated from coal fell from 31 TWh in 2012 to 15 TWh in 2016, because of growth in renewable power sources and a lower overall electricity demand.

Coal production decreased by 50% between 2012 and 2016, in line with the reduced demand for coal power generation.

Imported hard coal, almost all from the Russian Federation, is used in the cement sector. Industrial coal use accounted for 4% of the total coal consumption in 2015, a large drop from the high share of 20% in the mid-1980s, largely due to the decrease in coal consumption in the non-metallic minerals industry.

Figure 4.7 Coal consumption by sector, 1973-2015



* Negligible.

Notes: Coal in TPES by consuming sector. Consumption data per sector are available until 2015. Total coal consumption decreased to 4.4 million tonnes of oil equivalent in 2016.

Source: IEA (2017b), *World Energy Balances 2017*, www.iea.org/statistics/.

Market structure

Wholesale market and generation

The vertically integrated state-owned electricity company Public Power Corporation S.A. (PPC) dominates the electricity sector value chain. It accounts for 79% of the installed thermal generation capacity and for about 75% of thermal electricity generation. PPC's share in the day-ahead market, which includes imports, hydro, and renewable energy sources, was 53% in 2016. PPC's share in the retail market is about 88%. Amid decreasing electricity consumption, rising air pollution, environmental restrictions, and low gas prices, lignite production costs have been increasing. This trend is expected to continue as coal-fired plants are being replaced by plants fuelled by natural gas and renewables. Consequently, lignite consumption and production in 2016 has seen a downward trend. PPC is the dominant owner of lignite mines, and there were also a few private companies operating small lignite mines in 2016 (Achlada, METE, and LARCO).

PPC decommissioned 913 MW of lignite capacity in 2010-16, and plans to decommission another 2 112 MW by 2025. The company plans to commission two new lignite units with a total capacity of 1 100 MW during the period 2017-25. PPC has also expanded its gas-fired power plant fleet over the last five years, adding 1 700 MW. Production from PPC's gas-fired plants accounted for 11% of the total supply in 2016.

As PPC owns all lignite and hydro assets, large private generators are only engaged in gas-fired generation and renewables. Independent Power Producers (IPP) built eight gas-fired plants with a total capacity of 2 571 MW, which accounted for 16% of the

supply in 2016. This includes one self-supplying consumer, the country's largest industrial producer, Aluminium SA. Imports and exports of power are market driven, reflecting the price differentials among the Greek wholesale market and the prices in neighbouring countries. There are multiple private renewable energy source producers, and the share of renewable energy sources in the Greek power sector has been growing quickly, reaching 18% of the supply in 2016. PPC's lignite-fired generation continues to be one of the main suppliers, accounting for 23% of the installed capacity (4 337 MW) and 32% of the electricity generation in 2016.

Retail market

PPC maintained a market share of close to 88% in 2016, although 17 suppliers were active in the retail market. The second-largest alternative supplier market share was 2.9%.

The share of PPC has to be reduced to 50% by the end of 2019 as part of the economic adjustment programme. In consultation with the European Commission, the government resorted to an alternative mechanism to reduce the market share of PPC: the NOME[8] auctions, as per the new electricity market law (4389/2016) under which new entrants into the retail market are provided access to PPC's generation. The Regulatory Authority for Energy (RAE) determines the annual amount of electricity that will be available through auction sales of forward electricity products, while the electricity market operator (LAGIE) conducts the auctions. In the auctions, PPC sells around 40%, with an increasing trend, of its production from lignite and hydro units (over which it has a monopoly), which usually have lower production costs compared to the natural gas units of the IPPs. Therefore, the cost of IPP's fuel mix is reduced, which has a positive impact on the retail market through lower and more-competitive prices.

The NOME auctions allow for bilateral agreements between electricity producers and distributors. The first such NOME auction took place in October 2016, and bidders absorbed 460 megawatt hours (MWh) per hour, meeting the goal for the year. The second NOME auction took place in January 2017, when bidders absorbed 145 MWh per hour. The third auction was in July 2017, and bidders fully absorbed the quantity offered. NOME auctions and the increasing number of market participants are a positive first sign towards increasing the liquidity of the electricity market.

Retail tariffs were de-regulated on 1 September 2013, except for certain categories of vulnerable consumers as defined by a ministerial decision based on an RAE opinion. However, retail prices are not fully responsive to wholesale prices. RAE is intensifying the monitoring of price developments in the retail market. Customers have not availed themselves of the possibility to change supplier with a switching level of only 6%. RAE has identified several possible reasons for this general inertia due to a misperception about possible financial gains and the complexity of the switching process. The complexity of understanding the electricity bill, including several non-electricity related items like municipal tax and television charges, has also been identified as a possible barrier to changing suppliers.

[8] NOME is the acronym for Nouvelle Organisation due Marché de l'Electricité.

NIIs

The electricity systems on the non-interconnected islands (NIIs) are small. NIIs cannot benefit from the cost advantage of large-scale generation capacity and are commonly equipped with diesel-fuelled generators, which are expensive and not environment friendly. However, NIIs possess excellent conditions for solar and wind power. The integration of such resources based on renewable energy sources into the small island systems is complex due to their variability and the need for back-up from dispatchable generation capacity. The installed variable renewable energy source capacity is subject to constraints, in order to secure a continuous electricity supply to NIIs. But the framework for renewable energy source hybrid plants allows exploitation of the local renewables potential in a system-friendly manner.

The Greek regulatory system provides for a public service obligation (PSO) to supply power to consumers on NIIs at the same electricity prices as consumers on the mainland. Island suppliers are compensated for the difference between their (high) cost and the system marginal price on the mainland through a fund that is financed by a levy charged to all electricity consumers. The total cost for this PSO is in the range EUR 500 million to EUR 700 million per year. The levy amounted to EUR 65 to EUR 90 annually for the years 2014-16 for each meter point in the Greek electricity system. The benefits of enhanced connectivity of the NIIs with the main grid will include avoided cost in terms of diesel generation and (partial) reduction of the PSO for all electricity consumers.

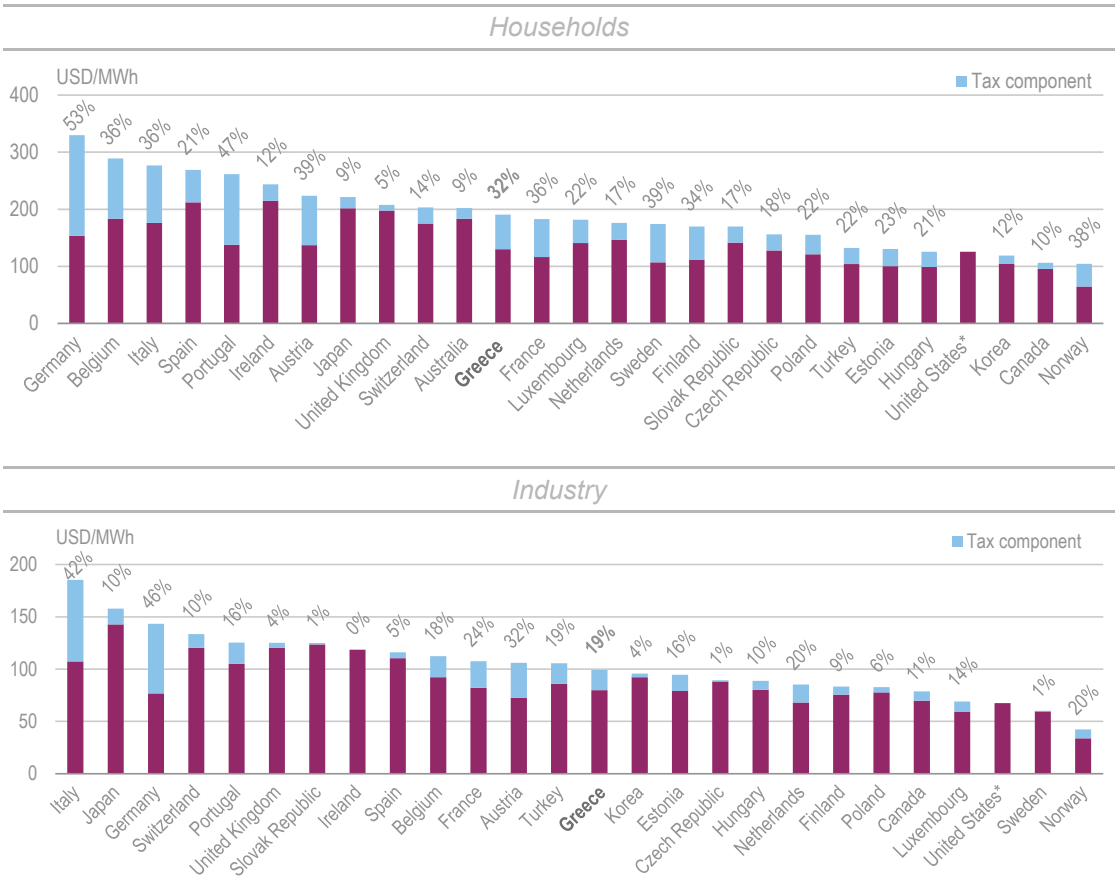
Prices

Greece fully liberalised its electricity prices with effect from 1 July 2013, depending on factors including: supply and demand; cost of generation, transmission, and distribution; and level of taxation. The electricity price for households in Greece was USD 191 per MWh in 2016, which was around the median of IEA member countries (see Figure 4.8). The tax component accounted for 32% of the Greek household electricity price (including all taxes, value-added tax, and levies), which was relatively high compared to the IEA average of 24%. The Greek industry electricity price was around the median of IEA member countries, at USD 99 per MWh. Tax levied on the industry electricity bill was 19%, slightly higher than the IEA average of 14%.

Electricity prices have followed the same trends as in neighbouring countries, with an overall increase over the last decade (see Figure 4.9). However, prices decreased by 30% in industry and 19% in households between 2014 and 2016.

Despite full price liberalisation, price regulation continues to exist under PSOs. These include the so-called supplier of last resort and the universal service supplier. The supplier of last resort provides a temporary supply to customers who lost their previous supplier for reasons that were not their fault. These contracts are limited to three months. Under the universal service obligation, regulated tariffs are offered to customers that either have not chosen a supplier of their own or are unable to conclude a new contract due to their poor payment record. The PSO programme includes vulnerable consumers benefiting from social tariffs and consumers on the NIIs. The cost of electricity generation in the NIIs involves high-cost diesel generators (around EUR 150 to EUR 250 per MWh), the price of which fluctuates with international crude oil prices.

Figure 4.8 Electricity prices in IEA member countries, 2016

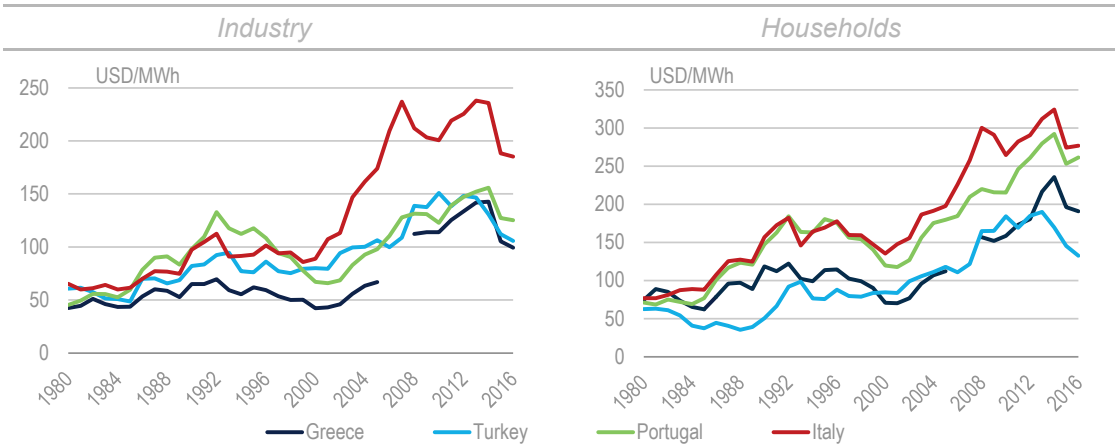


* Tax price not available.

Note: Data are not available for Australia (industry), and Denmark and New Zealand (industry and households). Exchange rate used: EUR 0.902 per USD.

Source: IEA (2017c), *Energy Prices and Taxes 2017*, www.iea.org/statistics/.

Figure 4.9 Electricity price trends in Greece and in other selected IEA member countries, 1980-2016



Note: Data are not available for Greece 2006-07. Exchange rate used: EUR 0.902 per USD.

Source: IEA (2017c), *Energy Prices and Taxes 2017*, www.iea.org/statistics/.

Greece introduced the social residential tariff in 2011 for the following categories of vulnerable consumers: 1) families with low income, 2) families with three or more children, 3) people who are unemployed, and 4) people requiring medical support. Over 600 000 consumers were eligible for the tariff in 2015. The tariff gives a discount of approximately 40% on annual consumption of up to 5 000 kilowatt hours (kWh). The cost of the consumption component not paid by the tariff beneficiary is shared by all consumers via PSOs. Greece introduced a preferential social solidarity tariff in 2014 to promote access to electricity of certified non-profit institutions. Furthermore, consumers with a low income are entitled to join a programme introduced in 2015 that provides free reconnection of the electricity supply, free consumption of 300 kWh per month, and social funding for house rental. About 70 000 consumers participated in this programme in 2015. Greece should opt for methods other than subsidising electricity prices to address energy poverty issues.

Legislative and regulatory market reform

Law 4001/2011 set the foundation for ongoing liberalisation of the Greek electricity market. The law transposed the third EU directive into national law and prepared for functional unbundling of the transmission system by moving from the independent system operator model to the independent transmission operator (ITO) model. The law also strengthened the energy regulator, RAE, by granting it financial autonomy and a distinct legal personality (see Chapter 1).

The government introduced comprehensive new legislation in 2011, which was implemented through regulatory and secondary legislation to reform the electricity sector. The key provisions of the new legislation include: additional strengthening of the financial and operational independence of RAE (Law 4425/2016), providing the framework for undertaking NOME auctions to enhance market competition, and privatisation of the ITO (Laws 4336/2015, 4389/2016, and 4393/2016).

Greece restructured the electricity market in 2012 for implementation of the ITO model by separating the former HETSO into the ITO Independent Power Transmission Operator (ADMIE), the market operator LAGIE, and HEDNO, the distribution network operator. HETSO was a 100% subsidiary of PPC, the vertically integrated government-owned utility in the electricity market. ADMIE was created by separating the physical transmission assets from PPC and merging them with the transmission business of HETSO. ADMIE was made legally independent but remained a 100% subsidiary of PPC, and RAE certified it as an ITO in 2012. ADMIE owns and operates the electricity transmission system, conducts real-time dispatch, and clears the imbalances and the settlement of all other charges or payments.

ADMIE is being privatised (Law 4389/2016) in line with commitments under the economic adjustment programme regarding the unbundling of networks entities, to complete the full ownership unbundling from PPC. ADMIE's share capital was divided into three separate parts: 51% was transferred to a holding company (ADMIE Participations S.A.), which is listed on the Athens Stock Exchange; 25% was transferred to a company controlled by the Greek State (DES ADMIE S.A.); and the remaining 24% share was sold to a strategic investor (State Grid of China) with the contract signed in mid-2017.

The remaining business of HETSO was renamed the Hellenic Electricity Market Operator (HEDMO), or LAGIE using its Greek acronym, the electricity market operator. LAGIE operates the day-ahead market and contracts, administers renewable energy sources, and also manages the special account for RES and CHP (RES = renewable energy sources; CHP = combined heat and power) (see Chapter 6). LAGIE was designated as the nominated electricity market operator in 2015 to perform single day-ahead and intraday coupling in accordance with Article 4 of Regulation No. 2015/1222. These are critical pre-requisite steps towards the introduction of the EU target model in 2018.

The distribution part of PPC was unbundled into a new independent company in 2012, called the Hellenic Electricity Distribution Network Operator (HEDNO), which is in charge of operating, maintaining, and developing the distribution network. HEDNO is also the system and market operator of the NIIs, and is a 100% subsidiary of PPC. A new distribution network code was issued in January 2017.

Market design

The Greek electricity market is operated as a mandatory pool in which scheduled demand and supply (production and imports) are matched only on a day-ahead market. LAGIE is in charge of day-ahead scheduling (DAS) and settles the day-ahead energy market based on the system marginal price, which is comparable to a day-ahead price as commonly used elsewhere in the EU.

There is no separate balancing market; instead, ADMIE clears the imbalance of the DAS through a special imbalance settlement mechanism in which deviations from the DAS are charged or compensated for based on the imbalance price. ADMIE is also responsible for the dispatch schedule, real-time dispatch instructions, and the settlement of all other charges or payments in the system. Cross-border trading is not based on so-called market coupling, and capacity is auctioned separately. Greece is moving towards market coupling with Bulgaria and Italy under the target model.

The system marginal price is computed by LAGIE, and the imbalance price calculated by ADMIE is derived from the same cost-minimisation algorithm. It is based on declared values submitted by generators, while the imbalance price is based on actual, metered values. The ex post clearance price corresponds to the uniform market clearing price. A price cap applies in the wholesale market. The cap was EUR 150 per MWh until 15 July 2016 when it was increased to EUR 300 per MWh. The mandatory pool is offering only limited degrees of freedom to market participants; it does not allow bilateral contracts and limits long-term hedging to over-the-counter financial products. This will change with the introduction of the EU target model in 2018.

Greece introduced a transitional capacity remuneration mechanism with regulated pricing on 1 May 2016, which expired on 30 April 2017. Gas-fired and hydro units that fulfil specific ramping requirements were eligible for capacity payments to compensate them for the availability of flexible generation. A permanent capacity payment mechanism may be introduced, depending on the outcome of the ongoing adequacy assessment. The growing penetration of variable renewable electricity and its priority dispatch has necessitated the assessment of introducing the mechanism. The purpose of the capacity remuneration mechanism is to ensure long-term capacity availability and to deal with market failures.

Greece is committed to moving towards the EU target model market (see Box 4.1) in the first half of 2018, and its parliament has approved the necessary legislation (4425/2016). The new electricity market model will consist of four markets (day-ahead, intraday, forward, and balancing markets; see Figure 4.10). Greece is preparing the necessary market codes. The law also specifies the responsibilities of RAE and market operators in transiting to and implementing the new electricity market to implement market coupling according to the EU target model.

Box 4.1 Greece and the EU target model market

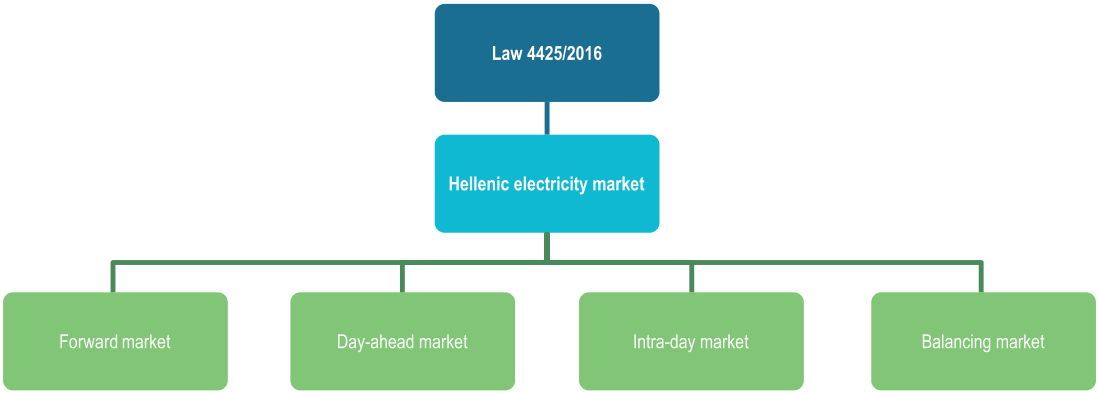
As part of Greece's commitment to adopt the European target model market, it passed legislation in 2016 for reform of the existing market structure towards four wholesale markets. Greece will introduce a forward, intraday, and balancing market over a transition period, to complement the day-ahead market. The main characteristics of the new markets are the following:

- A forward market with physical delivery operated by LAGIE. Forward products are important for the hedging of price risks, and are critical for retailers that seek to expand their customer portfolio and for generator investments decisions. They also reduce (even if eliminate) the scope for the exercise of market power.
- A new day-ahead market that will be an energy-only market without techno-economic constraints and which will be operated by LAGIE.
- An intraday market that will also be operated by LAGIE. Intraday markets allow renewable energy source producers to adapt their portfolio until close to real-time closure, allowing deviations between real and scheduled production and reducing exposure to the balancing cost. This is important for renewable producers now that they are increasingly exposed to market signals, as their actual production can only be predicted with high certainty a few hours before real time.
- A balancing market that will be operated by ADMIE. Balancing markets remunerate the real scarcity of electricity and can incentivise all parties to remain in balance, hence reducing the need for the transmission system operator to contract reserves and rendering intraday markets more liquid.

Intraday and balancing markets also allow remuneration of flexible units in a market context, they improve the investment climate for storage, and they incite the participation of demand in the market. This ensures that the market provides for the system flexibility required for cost-effective integration of wind and solar resources in the electrical system. The adoption of balancing requirements from renewable energy source producers is already foreseen under the legislation, but has, as a prerequisite, the existence of a liquid intraday market, to ensure equal opportunities.

Finally, market coupling optimises the usage of interconnection capacity, facilitates the development of liquid and competitive domestic markets, and enhances the security of supply. The actual implementation of the target market model requires a comprehensive set of regulations and other preparatory work, which will be undertaken in steps. Greece is in the process of preparing the necessary market codes.

Figure 4.10 New electricity market design



Transmission

ADMIE is the owner and operator of the Greek mainland transmission system, which comprises 11 508 kilometres (km) of transmission lines and 343 substations. The backbone of the transmission system consists of three double-circuit 400 kilovolt (kV) lines running north-south and additional single-circuit 400 kV lines running east-west. The bulk of the generation is located in northern Greece close to the lignite mines, while about 65% of the total consumption takes place in central and southern Greece. A 150 kV grid operates in parallel with the 400 kV grid.

There are in fact two electricity systems in Greece: the interconnected mainland system and the NII systems. The majority of inhabited islands are supplied through their own systems, although some located close to the mainland have already been connected to the mainland system. Operation and extension planning of the NII systems is the responsibility of HEDNO.

An ambitious part of ADMIE's grid expansion plan is the interconnection of some Aegean islands to the mainland system. These interconnections are considered a key priority. They will facilitate the high potential growth of renewable energy sources on the NIIs and will have a positive impact on electricity production costs, because the isolated systems rely on diesel generators.

Interconnections

Greece is connected with five neighbouring countries. The Greek system is connected to Albania, FYROM, Bulgaria, and Turkey through five single-circuit 400 kV alternating current lines, and has an asynchronous direct current link by a 400 kV submarine cable with Italy. In addition, there is a 150 kV alternating current connection with Albania. The interconnections are mainly used to import electricity, although Greece also exports electricity to Albania (see Table 4.2).

Table 4.2 Net transfer capacities (MW)

Neighbouring country	Net transfer capacity to	Net transfer capacity from
Albania	250	250
Bulgaria	400	700
FYROM	350	450
Turkey	216	166
Italy	500	500

Source: ENTSO-E (2016), *Mid-Term Adequacy Forecast 2016,* https://www.entsoe.eu/Documents/SDC%20documents/MAF/MAF_2016_FINAL_REPORT.pdf#search=greece.

Distribution

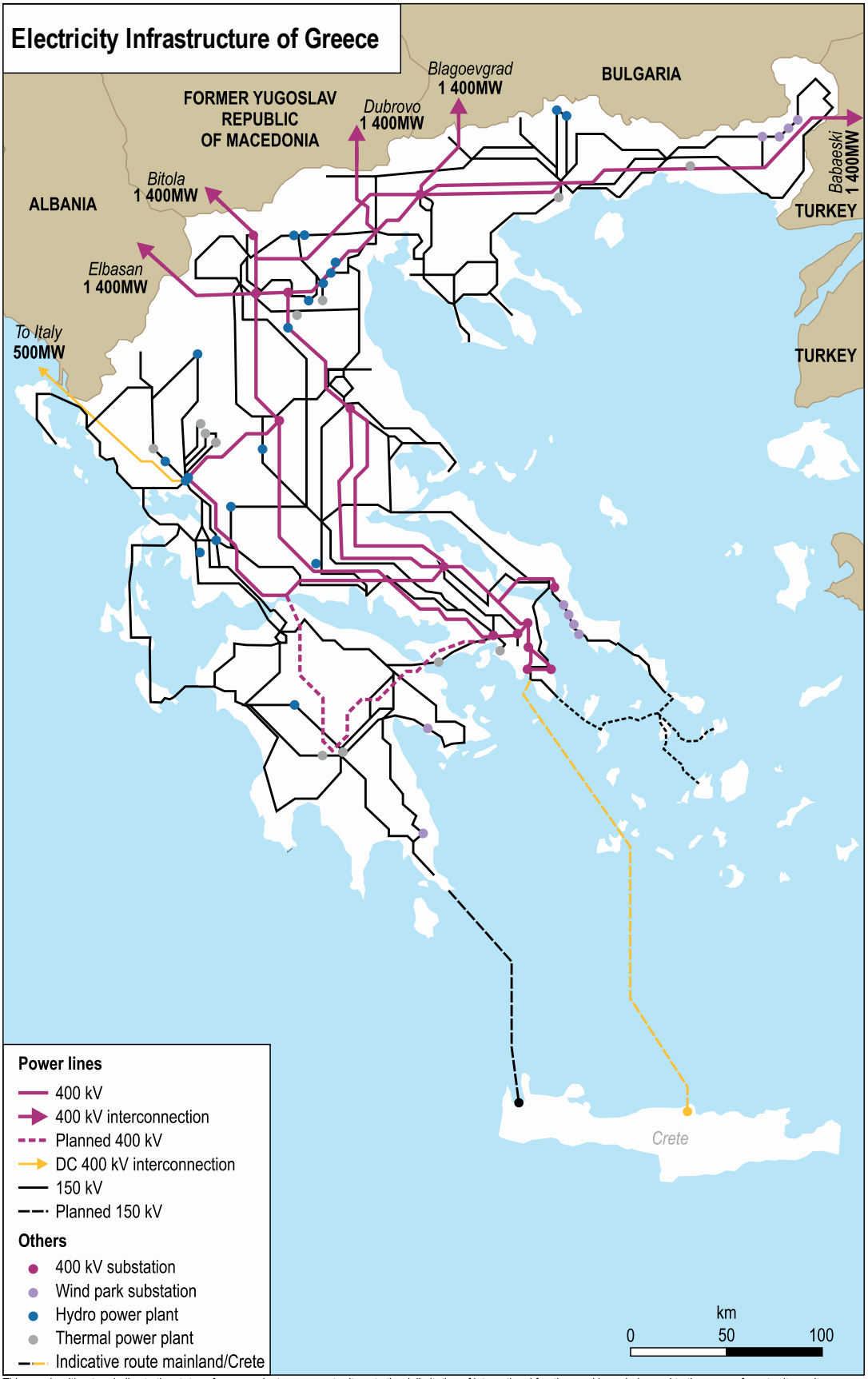
The distribution network consists of 237 390 km of medium and low-voltage lines and 945 km of high-voltage lines, and 225 high/medium-voltage and 161 900 medium/low-voltage substations. It is owned and operated by HEDNO, a 100% subsidiary of PPC. HEDNO services 7.4 million customers throughout Greece including on the NIIs, where it operates 32 electrical systems consisting of 31 isolated microgrids and one small isolated system on the island of Crete with a total installed capacity of 2 328 MW.

The newly adopted distribution network code describes a methodology for the calculation of allowed distribution revenues. The operation code for the NII was adopted in 2014, completing the secondary legislation to prepare for the introduction of market opening for production and supply in the NIIs.

Greece received derogation from the provisions of Article 7 of Directive 2009/72/EC for the NIIs, according to which authorisations for refurbishing, upgrading, and expanding existing conventional capacity within micro isolated systems can be granted directly to PPC. This derogation is valid until 1 January 2021 and is not applicable for new generation capacity.

Moreover, Greece received derogation from the provisions of Article 33 of Directive 2009/72/EC for up to five years after the adoption of the NII code or until the necessary infrastructure for market opening is in place. The retail markets for the islands of Crete and Rhodes are already open, and customers are free to choose their supplier; hence, the derogation does not apply there.

Figure 4.11 Electricity infrastructure



This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

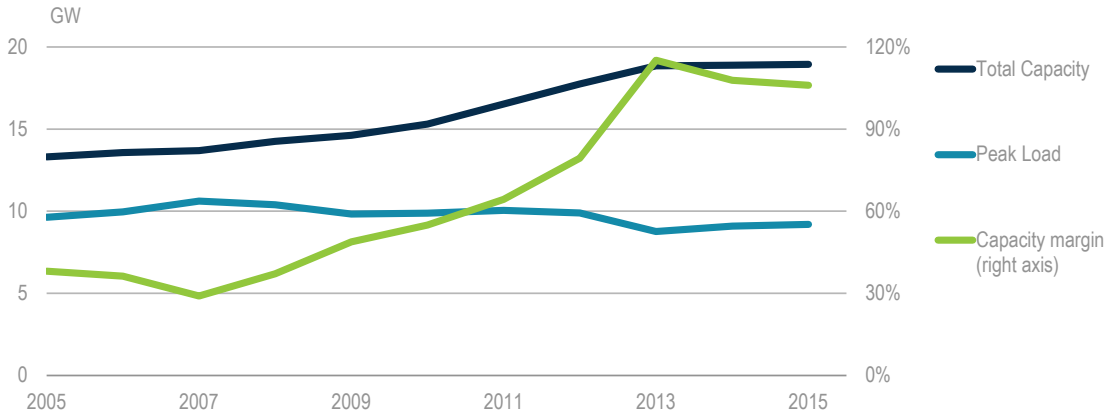
Security of supply

IEA in-depth reviews focus on the adequacy dimension of electricity security. Adequacy in this context refers to a power system's capability to meet changes in aggregate power requirements at present and over time, through timely and flexible investments, and operational and end-use responses.

Generation and fuel adequacy

During 2005-13, reserve capacity margins have improved in Greece, with new investments coming on line, notably natural gas and renewable energy, pushing the reserve capacity margin above 100%. However, since 2013, margins have been decreasing again, while peak demand and installed capacity have remained constant (see Figure 4.12).

Figure 4.12 Capacity margins in the electricity market, 2005-15



Source: IEA (2017a), *Electricity Information 2017*, www.iea.org/statistics/.

Greece has been pursuing a mix of supply and demand-side measures over recent years, to improve the security of supply by implementing a capacity remuneration programme, which has brought about investment in gas-fired capacity. RAE is reviewing this transitory electricity flexibility remuneration mechanism.

PPC has announced a large-scale decommissioning schedule, which will see around 55% of lignite units retire by 2030 (see Figure 4.13), in line with EU air pollution requirements (Integrated Emission Directive, 2010/75/EU). Security of electricity supply cannot be guaranteed beyond 2020-21, notably during extreme weather situations (cold or dry spells) due to the combined retirement of about 3 000 MW of old lignite plants (Kardia and Amydeo) (ENTSO-E, 2016).

The new lignite unit Ptolemaida (620 MW) is expected to come on line in 2022, and a range of new hydro storage plants and a new combined-cycle gas turbine plant with a capacity of 810 MW in Megalopoli are expected to balance supply and demand. However, long-term supply-demand forecasts and adequacy considerations beyond 2023 are challenging. They may require adjustments given the uncertainties about future economic growth and investment decisions. ADMIE expects that Greek electricity demand will increase to the pre-crisis (2008) level after 2020.

Peak load has shifted from midday to late afternoon in the summer months, due to increased solar photovoltaic penetration over the last few years. Increased use of electric heating has shifted annual peaks to the winter period.

The Greek power market has limited flexibility. Greece has around 3.3 gigawatts of hydro power plants that can provide flexibility and that are all owned by PPC. The few large industrial users do not participate in the Greek wholesale market, as there is not yet a balancing market, thus limiting flexibility. However, a system of interruptible contracts for large consumers is in place. The provision of flexibility will become important due to the increasing share of variable renewable energy, notably wind power.

The Greek power sector operates a mechanism of interruptible contracts that will expire towards the end of 2017. Under this mechanism, certain customers located in the interconnected system enter into contracts with ADMIE to reduce their consumption for a given period of time and within a pre-agreed notice time. These customers are compensated for their demand reduction. Each contract must provide a minimum of 3 MW of interruptible load. A maximum of 1 000 MW per year of interruptible load is auctioned by ADMIE. This mechanism is intended to be extended and will also be managed by ADMIE. It is important that a mechanism for interruptible contracts is available before winter 2017-18 as a response mechanism. A timely implementation of the permanent system will demonstrate the commitment of the government to provide a stable regulatory system to market participants, without gaps between successive regulatory measures.

The winter gas crisis in early 2017 illustrated the potential effect of gas shortages on electricity supply security. Electricity prices in Greece remained low during the gas supply crisis, as higher gas prices did not result in higher electricity prices. Gas-fired electricity exports from Greece increased because electricity prices increased in Turkey and the European Union due to cold weather, further exacerbating the gas crisis. Electricity prices in Greece did not respond in full due to the persistence of regulated prices, including the low wholesale cap. The recent increase of the cap in the wholesale market from EUR 150 to EUR 300 per MWh is expected to provide incentives to generators and demand-side response. An updated adequacy assessment should examine the level of reliability needed (value of lost load) and re-examine the related price cap.

Network adequacy

ADMIE annually prepares a ten-year network development plan that includes all network development projects covering the ten-year period ahead for the Greek interconnected system and for the interconnection of NIIs to the mainland system. The final plan is approved by RAE, following public consultation. Key considerations for the development plan are security of supply, integration of renewable energy sources, and increasing transfer capacities with neighbouring countries towards market coupling.

An ambitious part of ADMIE's grid expansion plan is the interconnection of some Aegean islands to the mainland system. These interconnections are considered a key priority because they will facilitate the growth of renewable energy sources on the NIIs and will have a positive impact on electricity production costs. The internal interconnection of some of the northern Cycladic islands is under construction, and is scheduled to come into operation in three steps by the end of 2017, 2019, and 2022. The first phase will connect Syros to the mainland and establish radial interconnections of Paros and

Mykonos with Syros; the second phase will link Naxos to Paros and Syros; and the third phase will establish a second link between Syros and the mainland system. This project is considered critical for the following two pillars of the government's energy policy: enhance security of electricity supply and support the development of renewable energy sources so that Greece can meet its renewable energy and greenhouse gas reduction targets. The Cycladic islands have great wind potential, a large part of which has not yet been exploited.

The interconnection with Crete is still at the planning stage, and is expected to be implemented in two phases (2020 and 2024), with two separate links being constructed. However, financing for this substantial project has not yet been secured.

Greece is actively enhancing its interconnections with neighbouring countries. The latest interconnection is the 400 kV line with Turkey that became operational in 2015. Plans for a capacity expansion of the connection with Turkey are being pursued, as are plans for a second interconnection with Bulgaria, which has received project of common interest status from the European Commission. ADMIE is pursuing the second interconnection with Bulgaria that is planned to become operational by 2021, with a view towards regional market integration and enhancing the security of supply.

Assessment

Wholesale electricity markets

Greece is undergoing a comprehensive and impressive reform programme that, ultimately, will result in competitive prices for the Greek electricity market and establish a level of regulatory maturity to the sector that will be attractive to investors.

Efforts to create a more competitive market structure on the retail and wholesale levels will reassure investors that market outcomes will be the result of competition based on merit only.

The Greek authorities should be commended for the efforts already made, which represent important steps in the emergence of electricity markets and which will produce market outcomes attractive to end customers and investors alike. It is now important to ensure that these reforms are implemented.

Greece organises its electricity market around a mandatory pool system with an ex post price settlement. The present mandatory pool system does not provide price signals for intraday or forward market products, nor does it provide for a separate balancing market. However, Greece will proceed with the wholesale market reform (target model) in 2018. Four markets are foreseen (forward, day-ahead, intraday, and balancing), according to the provisions of the target model. The introduction of this EU target model has the potential for more-efficient markets, in which risks can be better hedged, and is conducive to competition in wholesale and retail markets.

Greece operates electrical systems on some islands that are not interconnected with the main Greek interconnected system. Integration of variable renewable energy sources is less complex and more cost effective in a larger electrical system. The integration of the NIIs into the mainland system has therefore been a priority for many years. However,

only a few projects have secured funding. An increase of grid charges, due to the interconnection of the islands, balanced with a corresponding decrease of the PSO levy, could contribute to partially financing the construction of interconnectors. The expediency of interconnecting the NIIs may be improved by ensuring development is undertaken by ADMIE or merchant investors.

Greece has made commendable progress in setting up a regulatory framework for the provision of generation capacity and opening of retail markets on its NIIs. The good consumer switching rates on Crete and Rhodes illustrate that these reforms bear fruit.

Greece has limited flexibility from hydro power and demand response, but a temporary interruptibility programme is in place that will expire at the end of 2017. Greece should demonstrate its commitment to a stable regulatory framework attractive to investors by ensuring the timely prolongation and, if needed, the optimisation of the capacity payment programme (based on a system adequacy assessment). The aim should be to integrate demand response in the short-term markets (balancing and intraday) upon setting in force the target model.

Participation in the market of the demand side is important to increase the security of supply, as demonstrated in the gas/electricity crisis that Greece experienced in the winter of 2016/17. Demand response provides an important source of system flexibility if its activation is guided by price signals in a market designed to allow prices to reflect the real value of electricity and gas supplies when they are scarce.

The main challenge in the medium term up to 2025 is the retirement of old lignite power plants, in line with EU environmental requirements, and their expected replacement with several new projects, including gas-fired power plants, new lignite plants, and hydro storage. The production of lignite is considered significant for the country's energy security, as lignite is the only domestic fossil fuel resource in Greece. Moreover, the coal sector has social factors such as employment, which may be a key instrument from an economic perspective. Some coal-fired power plants could invest in modernisation and increase energy efficiency, which would require large investments because they are linked to coal mines. An assessment of the 2030 supply-demand outlook will need to be carried out when economic forecasts are clearer; this should include the contributions from imports, hydro plants, and demand response.

Retail electricity markets

Well-functioning liquid markets need engaged and aware customers who can access and evaluate market information. There are still large proportions of customers who are disengaged, although Greece has made achievements in this regard. The enhancement of competition should be addressed with priority.

Greece has made progress towards cost-reflective prices, although electricity prices include charges for social and environmental purposes. Electricity bills also include non-energy-related charges that can confuse customers. RAE should establish a programme with clear timelines and milestones to transition to cost-reflective retail prices. RAE determines the charges for network and grid operators, and also for environmental purposes.

Cash liquidity of the electricity supply chain can be improved by eliminating excessive charges on the electricity bill, for example, other taxes and fees not related to electricity

(e.g. television fees or local authority taxes). It is recommended that these are collected using other means.

Wholesale market trends are not appropriately reflected in retail prices, even though the electricity retail market opened up in 2007 and end user prices have been liberalised since 1 July 2013. Low energy prices present an ideal opportunity to start the process of implementing cost-reflective retail prices, if price convergence is achievable.

Various programmes for preferential tariffs for socially vulnerable groups exist. Close to 700 000 consumers were benefiting from these programmes in 2016. Greece should continue to tackle energy poverty issues and support vulnerable customers, but in ways other than via electricity prices and electricity bills.

Alternative suppliers have started offering and advertising competitive and innovative tariffs. These incentives can facilitate consumer access to information on their own consumption and send price signals that might become valuable information for sustainable and efficient energy use. The setting up of a supervised price comparison programme that is easily accessible (e.g. an online system) can enhance competition and help make an informed choice about possible switching. Therefore, initiatives to set up supervised price comparison websites might be suitable for promoting access to information on comparable prices and the process of switching.

Recommendations

Wholesale electricity markets

The government of Greece should:

- Expedite implementation of the electricity target model and enhance electricity wholesale and retail competition through the operation of effective intraday, balancing, and forward markets.
- Promote investments in electricity interconnections for the NIIs, using suitable financial tools.
- Demonstrate the commitment to a stable regulatory framework through adoption of measures to ensure the seamless continuation of a demand-response programme and optimisation of the capacity payment programme based on a system adequacy assessment.
- Evaluate the social, economic, and energy security effects of future coal-fired power plants and mine closures, taking into account all stakeholders.

Retail electricity markets and consumers

The government of Greece should:

- Modify the existing electricity distribution code to promote cost-effective flexibility options (demand-side participation, storage, batteries, etc.) for effective renewable system integration.

- Develop a clear and transparent programme for transition to fully cost-reflective retail electricity tariffs (based on the EU Clean Energy Package) while continuing to protect vulnerable consumers.
- Develop a transparent cost-reflective electricity price system and remove all non-energy-related charges from electricity bills, based on the legislative and regulatory framework that will be formed by taking into account the EU Clean Energy Package.
- Strengthen consumer engagement and information through electricity bills, by facilitating consumer switching and possibly introducing price comparison tools.

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5. Energy and climate

Key data

(2015)

GHG emissions without LULUCF*: 101.4 $MtCO_2$-eq, -3% since 1990

GHG emissions with LULUCF*: 98.17 $MtCO_2$-eq, -4% since 1990

CO_2 emissions from fuel combustion: 64.6 $MtCO_2$, -32% since 2005

CO_2 emissions by fuel: coal 36.6%, oil 54.2%, natural gas 8.4%, other 0.8%

CO_2 emissions by sector: heat and power generation 47.2%, transport 25.8%, industry 9.8%, other energy industries 6.4%, commercial and other services 2.5%, residential 8.3%

CO_2 (energy-related) intensity per GDP: 0.25 $kgCO_2$ per USD GDP PPP (IEA average 0.25)

**GHG data are from 2014 (source: MEEN, 2016).*

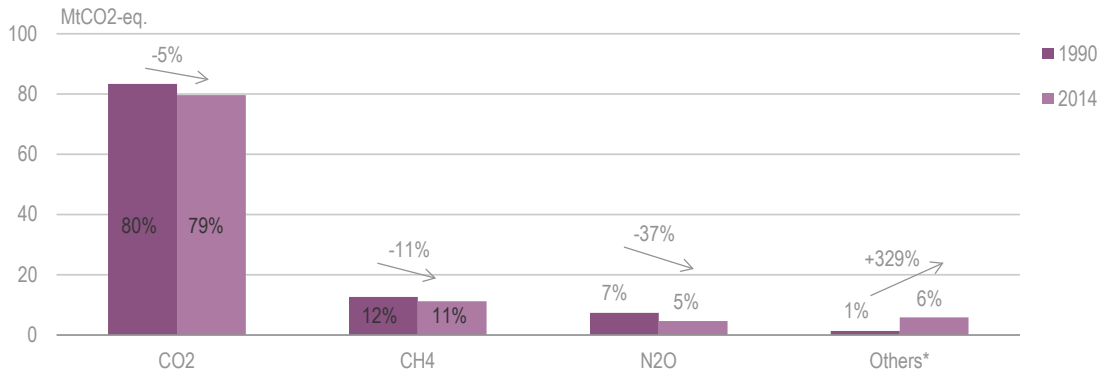
Overview

Greece's total greenhouse gas (GHG) emissions increased to a peak of 135 million tonnes of carbon dioxide equivalent ($MtCO_2$-eq) in 2005 and have since fallen to 101 $MtCO_2$-eq in 2014, which was below the 1990 level. The energy sector contributed 74% of the total GHG emissions (see Figure 5.1), and the main sources of energy-related carbon dioxide (CO_2) emissions are fossil fuel combustion in power and heat generation and transportation (see Figure 5.2). The decline in economic activity and related energy demand and the increase in renewable energy use in power generation have led to emissions reductions. Energy-related CO_2 emissions have fallen by 34% from their peak in 2007 to 2015, whereas final energy consumption fell by 25% over the same period. However, Greece maintains a high reliance on coal and diesel in electricity generation (especially on the non-interconnected islands (NIIs)), which results in a high carbon intensity of the economy. Greece emitted 582 grammes of carbon dioxide (gCO_2) per kilowatt hour (kWh), while IEA member countries emitted 390 gCO_2 per kWh in 2015. The carbon intensity of power generation fell by 26% between 2005 and 2015, due to greater deployment of renewable energy and natural gas.

As a member of the European Union, Greece has adopted European Union (EU) policies and measures to 2020, including the EU Emissions Trading System (ETS), covering the energy sector and large industries, and the Effort Sharing Decision, covering non-ETS sectors such as transport emissions. Greece is in a position to meet its emission targets, because of the economic contraction, and therefore has not implemented additional measures. Greece does not have a long-term energy and climate strategy, but it

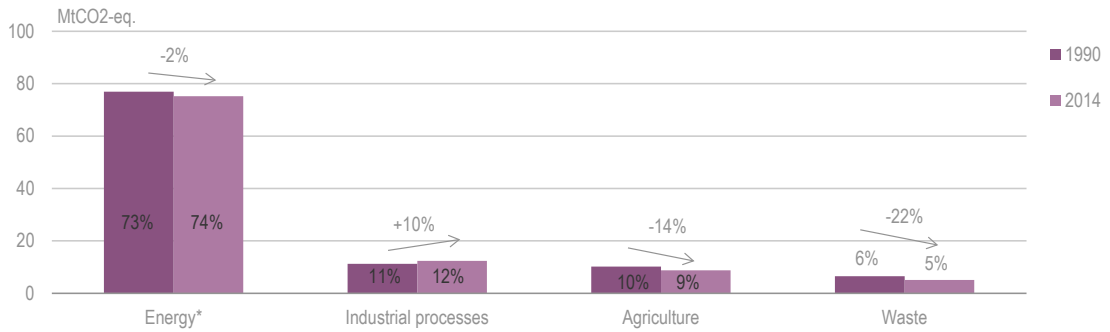
completed a 2050 energy roadmap in 2012. The government is preparing a national energy and climate plan by the end of 2017, as part of the EU 2030 Energy and Climate Framework.

Figure 5.1 GHG emissions by gas, 1990 and 2014



* *Others* includes hydrofluorocarbons, perfluorocarbons, and sulphur hexafluoride.
Source: MEEN (2016), *Climate Change Emissions Inventory*.

Figure 5.2 GHG emissions by sector, 1990 and 2014



* *Energy* includes emissions from transport, manufacturing industries, and construction.
Source: MEEN (2016), *Climate Change Emissions Inventory*.

Energy-related CO_2 emissions

Energy-related CO_2 emissions decreased by 8% between 1990 and 2015, from 69.9 million tonnes of carbon dioxide ($MtCO_2$) to 64.6 $MtCO_2$. Emissions grew steadily to a peak level of 98 $MtCO_2$ in 2007, but started falling with the 2009 economic crisis. The current level of emissions is the lowest since 1989. The crisis depressed economic activities in Greece, resulting in a decrease in energy consumption and energy-related emissions. Energy-related emissions also decreased due to the transition towards renewable energy sources. Greece reduced emissions by 34% from the peak in 2007 to 2015, whereas final energy consumption fell by 25% over the same period.

Emissions by sector

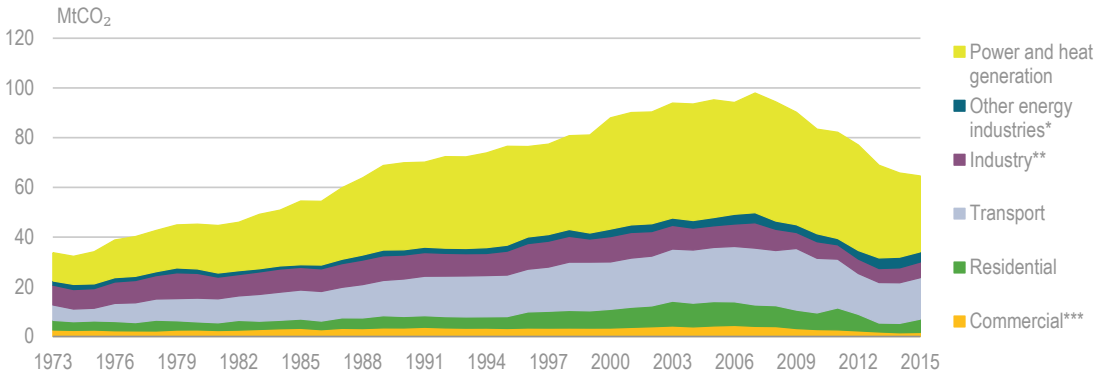
The largest CO_2 emitting sector is the power and heat generation sector (see Figure 5.3). Emissions from the power sector were 30.5 $MtCO_2$ in 2015, which accounts for almost half of the total energy-related CO_2 emissions. Between 2007 and 2015, emissions from

the power sector decreased by 37%, a result of the increased share of renewables in power generation and falling electricity demand. The share of renewables in power generation increased from 7.5% in 2007 to 28.9% in 2015. The electricity output decreased from 62.7 terawatt hours (TWh) in 2007 to 51.8 TWh in 2015, a reduction of 17%, and Greece reduced emissions by 34% over the same period.

The transport sector is the second-largest emitting sector, accounting for 25.8% of the total energy-related CO_2 emissions in 2015. Emissions from the transport sector decreased from 22.9 $MtCO_2$ in 2007 to 16.7 $MtCO_2$ in 2015.

All other sectors have also experienced a sharp decline in emissions in the past decade. Emissions from the industry sector fell from 10.2 $MtCO_2$ in 2007 to 6.3 $MtCO_2$ in 2015, a reduction of 38%, and similarly the residential and commercial sectors experienced 38% and 60% reductions in CO_2 emissions, respectively. The residential sector had emissions of 5.4 $MtCO_2$ in 2015 and the commercial sector 1.6 $MtCO_2$. While the economy's slow-down had a large effect on emissions reductions, replacement of oil with natural gas in the industry, residential, and commercial sectors has also contributed. The industry sector increased its natural gas consumption by 43%, while oil consumption fell by 47%, between 2007 and 2015. Similarly, fuel switching took place in the residential sector, where natural gas increased by 101% and oil decreased by 45%, and in the commercial sector, where natural gas increased by 85% and oil decreased by 52%, over the same period.

Figure 5.3 Energy-related CO_2 emissions by sector, 1973-2015



* *Other energy industries* includes other transformations and energy own use.

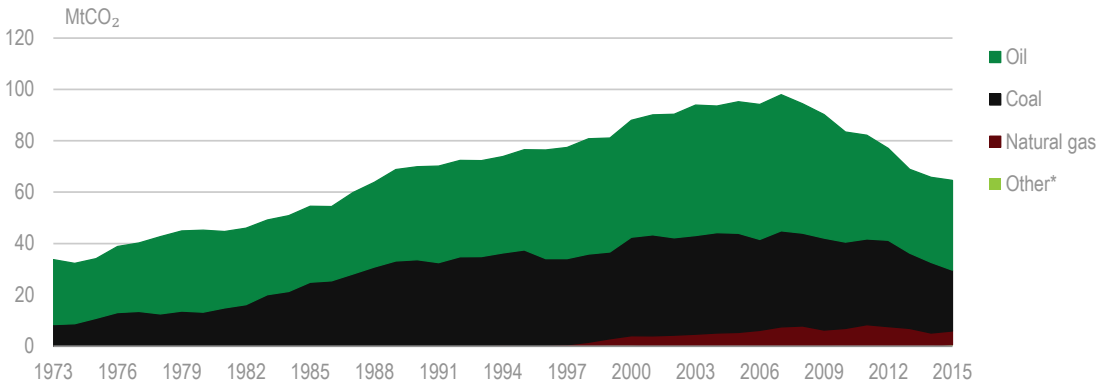
** *Industry* includes CO_2 emissions from combustion at construction and manufacturing industries.

*** *Commercial* includes commercial and public services, agriculture, forestry, and fishing.

Source: IEA (2017), *CO_2 Emissions from Fuel Combustion 2017 (OECD countries)*, www.iea.org/statistics/.

Oil generated the largest share of energy-related CO_2 emissions in 2015, accounting for 54% of the total emissions (see Figure 5.4). The other fossil fuels generated most of the remaining emissions, with coal accounting for 37% and natural gas for 8% of the total. Emissions from coal and oil increased until 2007, but this growth was offset by a large decline after the 2009 economic crisis. Natural gas emissions increased from negligible levels in 1990, to 8.2 $MtCO_2$ in 2011, accounting for 10% of the total emissions. The upwards trend was reversed after 2011, and the emissions from natural gas decreased to 5.4 $MtCO_2$ in 2015.

Figure 5.4 Energy-related CO_2 emissions by fuel type, 1975-2015



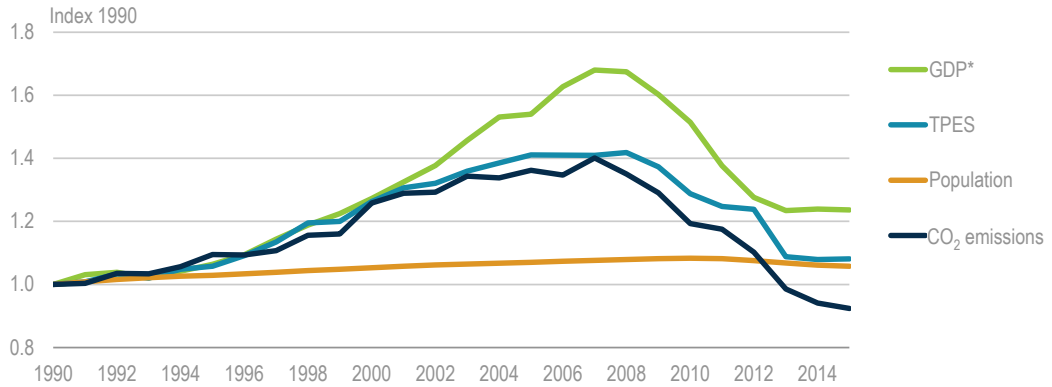
* Negligible.

Source: IEA (2017), *CO_2 Emissions from Fuel Combustion 2017 (OECD countries)*, www.iea.org/statistics/.

Carbon intensity

Important drivers for carbon emissions in an economy are population, gross domestic product (GDP), and energy consumption. These factors are often correlated because increased population and GDP tend to increase total energy demand and emissions. Between 1990 and mid-2000, the carbon intensity of Greece's economy improved, as GDP was growing at a faster pace than energy consumption and population (see Figure 5.5). However, the intensity slightly increased during the recovery from the 2009 crisis, and then decreased since 2012. Despite these fluctuations Greece's overall carbon intensity was lower in 2015 than in 1990.

Figure 5.5 CO_2 emissions and main drivers, 1990-2015

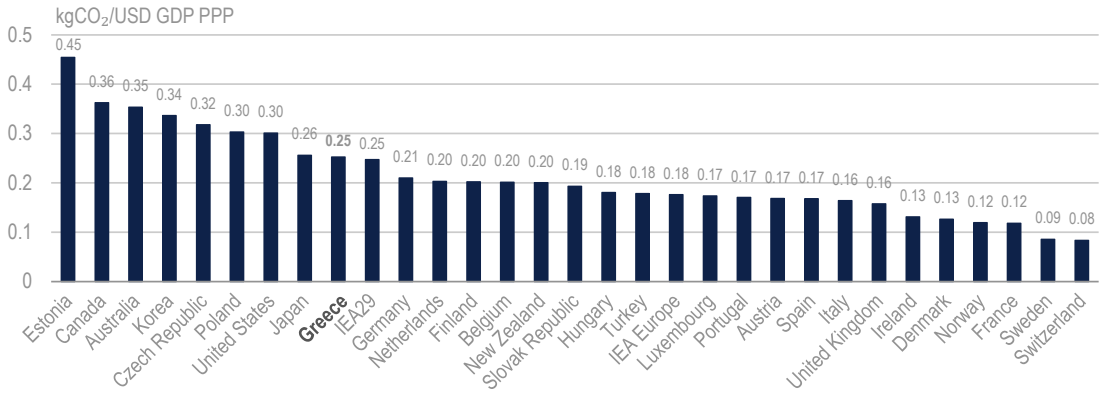


* Real GDP in USD 2010 prices and PPP.

Source: IEA (2017), *CO_2 Emissions from Fuel Combustion 2017 (OECD countries)*, www.iea.org/statistics/.

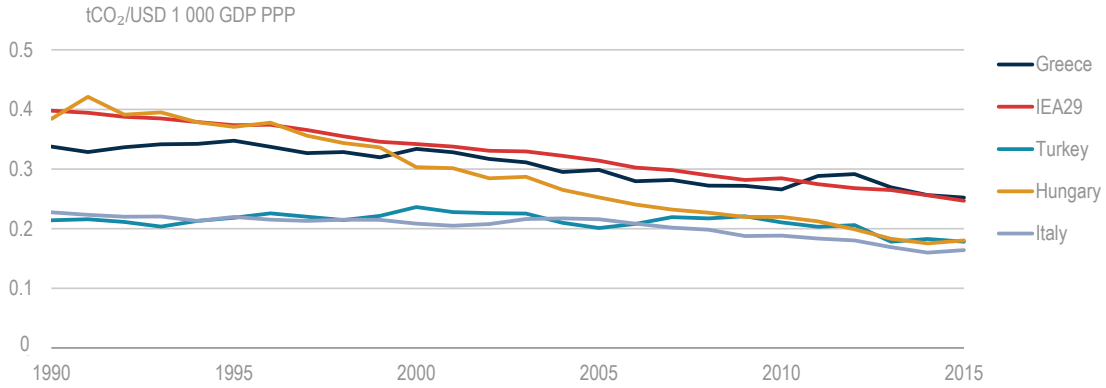
Greece has the ninth-highest energy-related CO_2 emissions per GDP among the 29 IEA member countries (see Figure 5.6). The carbon intensity has gradually decreased, from 0.34 kilogrammes of carbon dioxide ($kgCO_2$) per USD in 1990 to 0.25 $kgCO_2$ per USD in 2015. However, the reduction in Greece was not as large as in many other IEA member countries. Greece's carbon intensity was 15% lower than the IEA average in 1990, but the country's carbon intensity was equal to the IEA average in 2015 (see Figure 5.7).

Figure 5.6 Energy-related CO_2 emissions per unit of GDP in IEA member countries, 2015



Source: IEA (2017), *CO_2 Emissions from Fuel Combustion 2017 (OECD countries)*, www.iea.org/statistics/.

Figure 5.7 Energy-related CO_2 emissions per unit of GDP in Greece and in other selected IEA member countries, 1990-2015

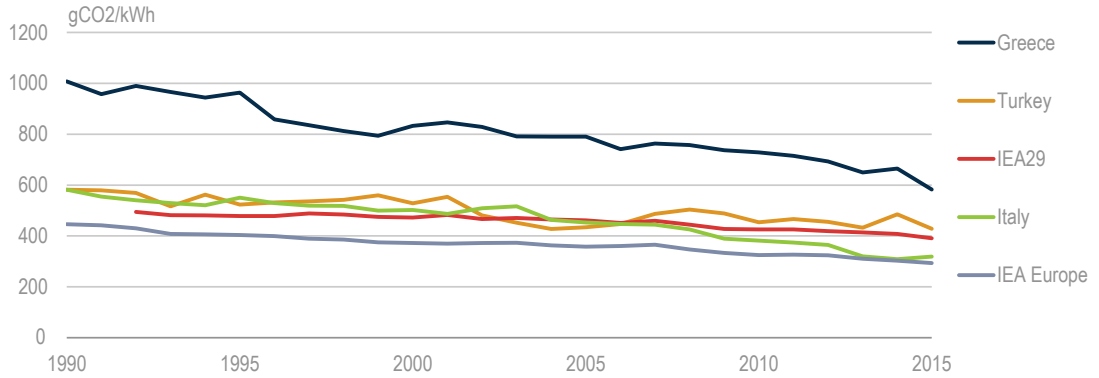


Source: IEA (2017), *CO_2 Emissions from Fuel Combustion 2017 (OECD countries)*, www.iea.org/statistics/.

The main reasons for the high carbon intensity of the Greek economy are the emissions from power generation, which are high compared with the IEA average. Greece emitted 582 gCO_2 per kWh (see Figure 5.8) in 2015, while IEA member countries emitted 390 gCO_2 per kWh. The heavy reliance on fossil fuels in power generation, primarily lignite, is the main reason. Fossil fuels generated over 70% of the electricity in 2015 (the share in the NIIs of Greece was even higher due to the high use of diesel generation).

Overall, the carbon intensity of power generation has steadily decreased, as sources that are less carbon intensive, such as natural gas and renewables, have largely replaced oil and coal. Over the past decade, the share of electricity generated from renewables in total power generation increased from 11% to 29% and that from natural gas increased from about 14% to 28%. The carbon intensity of power generation therefore fell by 26% between 2005 and 2015.

Figure 5.8 CO_2 emissions per kWh of heat and power in Greece and in other selected IEA member countries, 1990-2015



Source: IEA (2017), *CO_2 Emissions from Fuel Combustion 2017 (OECD countries)*, www.iea.org/statistics/.

Energy and climate policy

The government's declared policy is to diversify energy sources and reduce the CO_2 intensity of the economy while increasing energy security. Climate change has not been a priority for Greece in the past, as the use of lignite has been a strategic choice, despite its environmental impact, because it is the only domestic fossil fuel.

Policies and measures under the EU 2020 Package set the country's energy policy as follows:

- a reduction of GHG emissions by 20% from the 1990 level by 2020
- an energy efficiency target of 24.7 million tonnes of oil equivalent (Mtoe) in primary energy consumption or 18.4 Mtoe of final energy consumption by 2020
- a renewable energy share of 20% in the gross final energy consumption (beyond the 18% EU target) by 2020
- an EU-ETS and a national target under the EU Effort Sharing Decision to reduce GHG emissions outside the EU-ETS by 4% by 2020.

Greece does not have any national climate change or emissions reduction targets outside of the EU framework. For 2020, it contributes to the EU-wide efforts to reduce GHG emissions by 20% by 2020, from 1990, through the EU-ETS, and a national effort sharing that requires Greece (EU Effort Sharing Decision) to reduce GHG emissions by 4% by 2020, outside the ETS sectors. The EU-ETS covers 145 installations and 19 aviation operators in Greece.

Greece set targets and measures prior to the financial and economic crisis. Greece could increase both its emissions and final energy consumption because energy demand has decreased substantially since the crisis. The country is making progress to meet its 2020 renewable target, as it aims to reach a share of 20% of renewable energy in the final energy consumption by 2020, which is 2% above its EU obligation. Greece has not adopted additional carbon policies, and the 2020 targets do not act as additional policy drivers, because Greece expects to meet its emissions and renewable energy targets.

Greece ratified the Paris Agreement in October 2016 as part of the EU ratification process of the EU nationally determined contribution (Law 4426/2016). The country has no separate nationally determined contribution, but is part of the EU target to achieve at least a 40% domestic reduction in GHG emissions by 2030, from the 1990 level. A 43% reduction is expected from the ETS sector, based on the reformed EU-ETS after 2021, while all other sectors should contribute, with a 30% reduction compared to 2005 under the new Burden Sharing Proposal for 2021-30 (July 2016). This proposal requires Greece to cut emissions by 16%, which is a much higher cut than that during the previous period (4%).

Greece has to comply with EU air pollution requirements, notably Directive 2010/75/EU on industrial emissions (the Integrated Emission Directive (IED) on integrated pollution prevention and control) and the strict emission limit values of its Annex V, which apply, as of 1 January 2016, to large combustion plants with regard to sulphur dioxide, nitrogen oxides, and particulates from installations with a thermal input capacity above 50 megawatts (MW). Flexible mechanisms allow temporary derogations from the emission limit values for some plants meeting specific conditions (Chapter III of the IED). Transitional national plans (Article 32) for complying with the new emission limit values apply from 1 January 2016 to 30 June 2020. Fixed-term lifetime derogations to 31 December 2023 are available for those plants that limit their operations to a maximum of 17 500 hours of activity (Article 33), and which have not operated more than 20 000 hours during the period 1 January 2008 to 31 December 2015 (Article 4(4) of Directive 2001/80/EC). Combustion plants in small isolated systems (Article 34) have derogations until 2019, if they were part of a small isolated system on 6 January 2011.

Greece adopted a transitional national plan (TNP, 2012, amended in 2014) for the period 2016-20 with maximum total annual emissions defined for all of the plants covered by the plan (Meliti 1, Megalopolis 3 and 4, and Agios Dimitrios 1, 2, 3, 4, 5). The oldest plants of the Public Power Corporation (PPC) have used the limited lifetime derogation under Article 33 of Directive 2010/75/EU (Ptolemaida 5, and Kardia 3 and 4). These units are expected to shut down in 2019 and 2023, after the end of the derogations, as it is a significant investment to install flue gas desulphurisation. PPC closed eight lignite units and four oil-fired units during 2010-16. An additional 2 gigawatts will no longer be able to operate by 2023, because they will not meet the environmental and emissions standards.

It is estimated that 55% of lignite capacity will be decommissioned by 2030, while there are two new coal plants being envisaged (Ptolemaida V, 650 MW, under construction, and Meliti 2, 450 MW, planned by 2025), as shown in Chapter 4 on electricity. Lignite consumption is affected because of gradual decommissioning of the old lignite power stations. Lignite is highly carbon-intensive, and the EU-ETS penalises lignite-fired generators, requiring the purchase of allowances to cover their emissions.

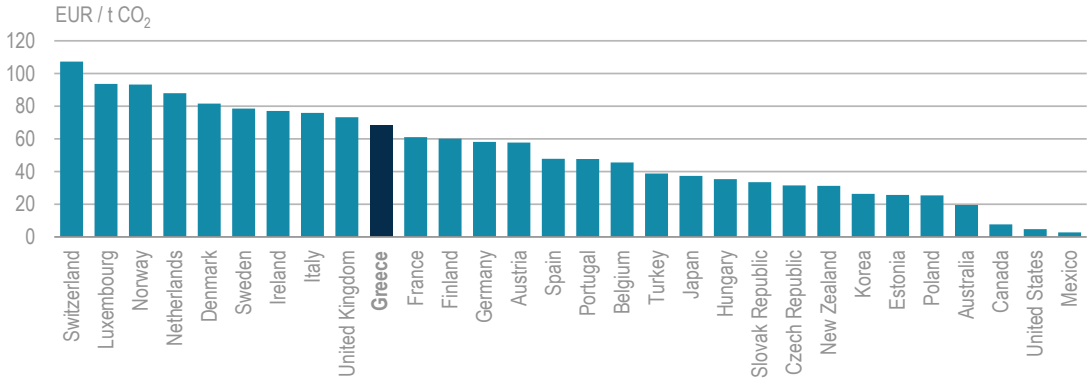
Effective carbon prices and energy taxes

The effective tax rate on CO_2 from energy in Greece was EUR 68 per tonne of carbon dioxide (tCO_2) and is ranked the tenth-highest tax rate among IEA member countries (OECD, 2015). Environment-related taxes on energy and motor fuels amounted to around 2.8% of the GDP in 2014, which is higher than the Organisation for Economic Co-operation and Development (OECD) average value (2%). The average tax on energy use in Greece was EUR 4.37 per gigajoule (GJ) on an economy-wide basis (see Figure 5.9).

Greece imposed, in 2014, a higher average tax rate on transport fuels, such as gasoline and diesel (EUR 15.49 per GJ), than on fuels used for heating and process heat purposes (EUR 1.38 per GJ) or electricity generation (EUR 0.85 per GJ).

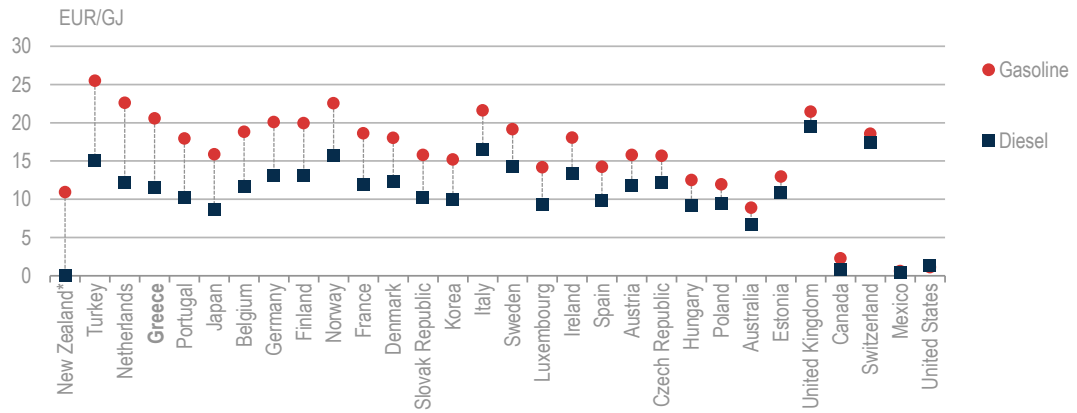
There is a high differential between taxation of diesel and gasoline (see Figure 5.10). The absolute tax rate difference between gasoline and diesel was EUR 9.1 per GJ. Taxes on gasoline by energy unit are 79% higher than those on diesel. Diesel is favoured in fuel taxation in most EU member states, and countries aim to reduce the differential over time.

Figure 5.9 Tax rates on CO_2 from energy in IEA member countries, 2014



Source: OECD (2015), *Taxing Energy Use 2015: OECD and Selected Partner Economies*, http://www.oecd.org/tax/taxing-energy-use-2015-9789264232334-en.htm.

Figure 5.10 Tax rate difference between gasoline and diesel, 2014



* New Zealand is the only OECD country to apply an excise duty to gasoline but not to diesel; diesel vehicles are subject to a distance-based road use charge.

Source: OECD (2015), *Taxing Energy Use 2015: OECD and Selected Partner Economies*, http://www.oecd.org/tax/taxing-energy-use-2015-9789264232334-en.htm.

Long-term energy scenarios and planning

In April 2012, the Ministry of Environment and Energy presented a National Energy Plan: Roadmap to 2050 for Greece, which was developed by the National Committee for Energy Planning, established by Law 3438/2006.

The 2050 roadmap concluded that the existing policies scenario will not lead to the required reduction of CO_2 emissions by 2050 in the energy sector. The roadmap

considered two alternative energy policy scenarios: 1) a scenario for measure maximisation and 2) a scenario for minimisation of the cost of environmental measures (next to maximising emission goals, the renewable energy deployment cost is also considered). Based on the two scenarios, the roadmap sets out the following vision for the future Greek energy system:

- reduce GHG emissions by 60%-70% by 2050 compared to the 2005 level
- produce 85%-100% electricity generation from renewable energy sources with all commercially mature technologies
- develop a 60%-70% penetration of renewables in gross final energy consumption by 2050
- stabilise energy consumption due to energy saving measures
- relative increase electricity consumption due to electrification of transport and greater use of heat pumps in the residential and tertiary sectors
- significantly reduce oil consumption
- increase the use of biofuels in the transportation sector by 31%-34% by 2050
- create a dominant share of electricity in short-distance passenger transport and an increase in the share of public transport
- enhance the energy efficiency of building stock and develop a high penetration of renewable energy sources in buildings
- develop decentralised production units and smart grids.

Electricity generation costs follow a decreasing trend after 2030, while the increased use of renewables and the limited use of fossil fuels ensure cost reductions by 2050.

The scenarios have been built on the assumption that economic demand will recover quickly. However, energy demand has continuously decreased since 2008 (with a small rebound in 2014 and 2015), which makes any energy efficiency progress or attracting energy infrastructure investment even more challenging. The future rebound of energy demand cannot be forecast; therefore, it is difficult for policy makers to define appropriate and realistic targets beyond 2020 for 2030. Greece is developing a roadmap of policies towards 2030 through the preparation of a national energy and climate plan.

Climate adaptation

Greece's main economic sectors are severely affected by the impact of climate change due to the country's location in the Mediterranean. Key effects for Greece relate to decreases in water availability and crop yields, increasing risks of droughts and forest fires, biodiversity loss, and adverse effects on human health/well-being and livestock. The Greek energy sector will be affected by decreasing water availability, which will have a direct impact on hydro basin levels, the availability of cooling water for thermal power plants, and increasing energy demand for cooling, particularly in summer.

Greece developed a first national strategy for climate adaptation based on the 2014 memorandum of understanding among the Ministry of Environment and Energy and various academic stakeholders. The government is preparing regional climate adaptation plans and aims to create a national observation and co-ordination system in 2018-19.

Technology research and development

Energy and environment is one of eight priority areas of the new Greek Strategy for Research and Innovation (GSRI 2014-20), based on the national research and innovation strategy for smart specialisation. There are 13 regional strategies for research and innovation, in addition to the national strategy, one for each region of Greece. Nine of these regional strategies include energy as a specific priority area (see Figure 5.11).

The General Secretariat for Research and Technology, under the Ministry of Education, is responsible for designing and implementing the GSRI, but the Ministry for Development was the lead until 2013. This secretariat applied a comprehensive and inclusive bottom-up process for the design of the GSRI by nominating experts from academia, research institutes, and the private sector into a platform to help shape the priorities within each area. The steering group for the energy sector identified seven segments based on this bottom-up approach: 1) energy efficiency; 2) energy production from renewable sources; 3) energy technologies for agriculture and the environment (biobased industry); 4) energy storage; 5) hydrogen and fuel cells; 6) technologies for smart grids; and 7) fossil fuel impact reduction. The steering group also identified an extensive subset of priorities within each of the seven energy research and development (R&D) areas.

There is no inventory that tracks public and private spending on energy R&D and the institutions and research groups that benefit. The government is undertaking biannual surveys to obtain data on private sector investment in R&D; however, those surveys do not appear to be systematically analysed and their findings fed back to public sector funding.

Funding for the ongoing period of the overall strategy increased by 50% compared to the previous period (2007-13), up from EUR 1 billion to EUR 1.5 billion. The share of energy in the total R&D budget increased from EUR 30 million for the period 2007-13 to around EUR 100 million for the ongoing seven-year period. A first call for energy R&D tenders for a total of EUR 31 million closed on 17 April 2017. The first tender exceeds the spending on energy for the entire previous period.

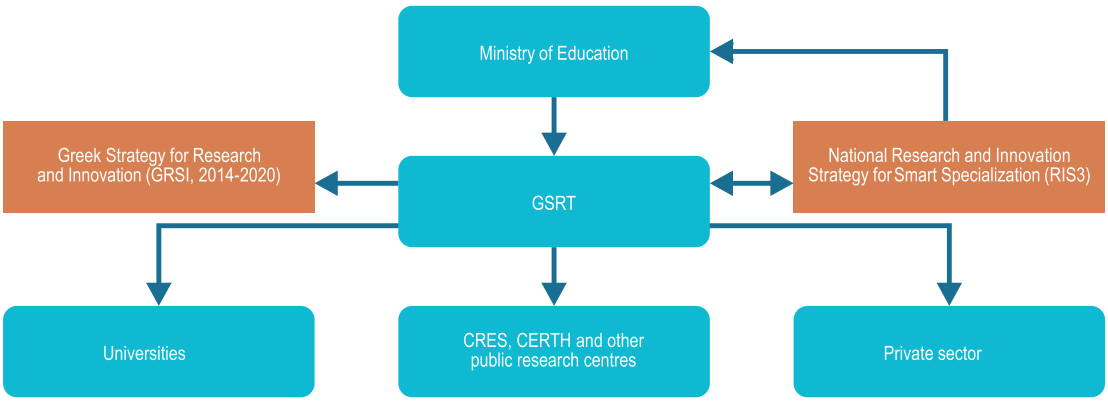
Greece's R&D programme greatly benefits from EU funding, notably from the structural and regional funds and the EU framework programmes for research (FP7, Horizon 2020) to support its GSRI. Energy themes and priorities, as well as funding criteria in GSRI, are aligned to the EU programmes. Boosting private sector R&D remains a challenge, as fiscal consolidation has negatively affected public spending on research, development, and demonstration (RD&D).

Greece is involved in bilateral R&D activities with the People's Republic of China, the Russian Federation, Germany, and Israel; it is also supporting multilateral research activities, including through the technology collaboration programmes (TCPs) of the IEA.

Greece is collaborating internationally in areas where it has leadership, including solar thermal collectors and renewable energy. Greece participates in five TCPs, three focusing on renewable energy technologies (hydrogen, concentrating solar, and wind), one working to advance fluidised bed converters, and another focusing on modelling and scenarios. The Centre for Renewable Energy Sources and Saving (CRES), a public entity supervised by the Ministry of Environment and Energy with financial and administrative independence, manages many TCPs and EU programmes. CRES and the Centre for Research and Technology Hellas Greece, participate in TCPs focusing on renewables, while the Institute for Solid Fuels Technology and Applications and the Scientific Research and Technology Service of the Ministry of Co-ordination participate in the TCP focusing on modelling and scenarios.

The Energy Conservation Group, within the Institute for Environmental Research and Sustainable Development, and the Solar and Other Energy Systems Laboratory, of the Demokritos National Centre for Scientific Research, also contribute to EU programmes. Greece created the Greek Institution of Research and Innovation with energy and environment as a priority area. This institution finances doctoral and post-doctoral research with a confirmed budget for the period 2017-19.

Figure 5.11 Energy RD&D landscape



Assessment

Greece has seen a reduction in GHG emissions, amid decreasing GDP and energy demand. Emissions have reduced at a higher rate than energy consumption has decreased, owing to the increases in the use of renewable energy sources and natural gas.

However, the power sector maintains a high carbon intensity of 582 gCO_2 per kWh, above the IEA average. Greece still uses oil in heating (and for power generation on the NIIs) and lignite in power generation. This has the potential to become the main challenge of climate policy and emission pathways, once the economy recovers. The large coal-fired power plant fleet is ageing and running fewer hours, while costs for environmental refurbishment increase. The Greek NIIs, which still rely on high-cost diesel-generated power, are looking at cheaper and cleaner options. The pathway towards a more-sustainable and affordable economic development has become critical since the severe financial and economic crisis since 2009.

The Greek energy mix has experienced changes relating to the decreasing role of coal with an ageing fleet since the past IEA in-depth review. Lignite-fired plants accounted for 45% in power generation in 2011, but this decreased to around 32% in 2016. The fleet is old and will come to the end of its commercially and environmentally useful lifetime by the mid-2020s. A reduction of 55% of the installed coal capacity of PPC is expected by 2030. At the same time, renewable energy is growing, notably the use of solar photovoltaics has seen a rapid increase in recent years. Natural gas is now almost cost-competitive with lignite in the electricity mix, reflecting the EU-ETS price and lower international gas prices, and can become an important transition fuel, together with growing contributions from renewable energy.

Greece has national obligations from the EU 2020 Climate and Energy Package of 2009, including emissions reduction targets, targets for the share of renewable energy, and energy efficiency targets. Greece has put in place policies that incentivise or support energy conservation, energy efficiency, or the use of renewable energy, which thereby contribute to the mitigation efforts of GHG emissions. Greece has raised the level of fuel taxes and duties, and achieved an average effective tax rate on CO_2 of EUR 68 per tCO_2 in 2015 (OECD, 2015), which is a comparatively high effective tax rate on CO_2 from energy among OECD countries. Other instruments such as the recently adopted energy efficiency obligation programme or the new market-based support programme for renewable energies have the potential to decarbonise the Greek power sector and economy.

All climate and energy policies originate from EU initiatives or obligations. This results in two main risks, which could lead to additional challenges for the Greek energy system and its economy as a whole. First, without a long-term national climate policy strategy, it is difficult to balance and optimise different options to reduce GHG emissions and to specify instruments according to the long-term potential and needs of Greece. Second, Greece should be better prepared to cope with potential future technical, social, or economic developments, as well as any possible future obligations that may arise from EU or other international commitments.

The energy system transformation has become a high priority for the government. Possible pathways of the energy sector for 2030 have not been evaluated, as there is uncertainty about the horizon beyond 2020 in terms of economic recovery and rebound and the actual transformation of the energy system. This is an area where government leadership will be required to design long-term stable policies beyond 2020 to 2030. Building on the 2050 energy roadmap, the government should set out robust energy sector planning to guide energy investment in line with future transformation. A national energy and climate plan for 2030 is under preparation.

The economic recovery will affect future energy demand. Greece plans the construction of two new coal plants by 2030. The winter supply crisis in 2016/17 illustrated that energy security may not be ensured in a high-demand and peak-load scenario. Energy security must be kept under review as coal plants come to the end of their lifetime. The government should examine the modernisation/renovation of old power plants, promoting the use of alternative fuels, increasing interconnection of NIIs to reduce diesel generation, and promoting new gas, liquefied natural gas, and other storage infrastructure.

The speed and scope of the energy system transformation will depend on technology development. Greece will be a technology taker in many areas. Energy and environment is one of eight priority areas of the GSRI, based on the national research and innovation strategy for smart specialisation, under the Ministry of Education. The smart specialisation approach to R&D priority setting may not obtain the best value for investment in the new institutional structure. A consolidation of areas eligible for funding should be considered. The GSRI should facilitate the monitoring and assessing of R&D activities and funding, which has not been carried out consistently in past years. The Ministry of Environment and Energy should assess technology perspectives for the long-term development of the energy sector and establish an inventory of funded projects to support their development along the R&D and innovation value chain.

Recommendations

The government of Greece should:

- ☐ Align its ambitions for energy efficiency, fuel switching, and renewable energy for 2030 in line with the 2050 energy roadmap, to ensure emissions reductions during Greece's economic recovery.
- ☐ Update and publish scenarios of future power demand/supply outlook to 2030/2050, to guide investments in generation and networks.
- ☐ Develop an energy research strategy, in the Ministry of Environment and Energy, and strengthen the overall institutional governance of energy R&D within the government and with academia and industry in support of a long-term technology vision for the energy sector; focus energy R&D activities to maximise the value to the Greek economy within the limited budget.
- ☐ Establish an inventory of public and private energy R&D projects and funding to allow for enhanced monitoring of the allocation of the budget; similarly apply established indicators to evaluate the value/outcome of the projects supported.

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TNP (Transitional National Plan) (2012), *Greece TNP Amendment*, 2014, https://circabc.europa.eu/faces/jsp/extension/wai/navigation/container.jsp.

6. Focus area 1: Renewable energy

Key data

(2016 provisional)

Total supply: 2.9 Mtoe (12.5% of TPES) and 15.0 TWh (30.7% of electricity generation); IEA average: 9.6% of TPES and 24.2% of electricity generation

Hydro: 0.5 Mtoe (2.1% of TPES) and 5.5 TWh (11.4% of electricity generation)

Biofuels and waste*: 1.4 Mtoe (6.1% of TPES) and 0.4 TWh (0.7% of electricity generation)

Wind: 0.4 Mtoe (1.9% of TPES) and 5.1 TWh (10.5% of electricity generation)

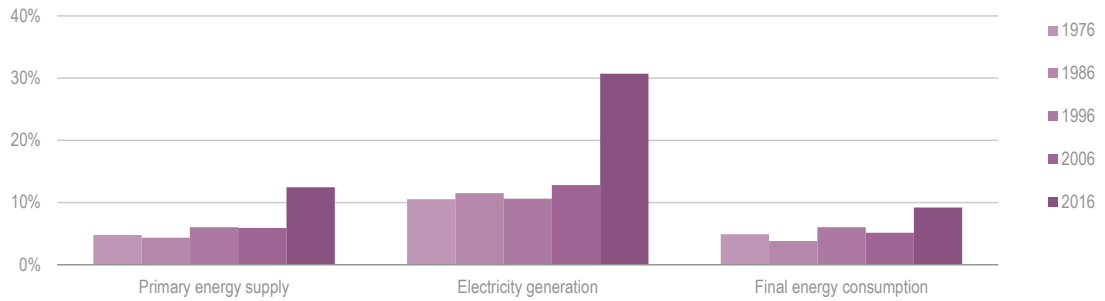
Solar: 0.5 Mtoe (2.3% of TPES) and 3.9 TWh (8.1% of electricity generation)

**Biofuels and waste includes solid, liquid, and gaseous biofuels plus municipal and industrial waste.*

Overview

Greece has large renewable energy resources, and the share of renewables has seen growth in wind and solar photovoltaics (PVs) in recent years (see Figure 6.1), thanks to generous feed-in-tariffs (FiTs) and decreasing technology costs. Greece is developing competitive auctions for solar PVs and wind. It is also developing market-based premiums to avoid large cost overruns, as it transitions to a new support programme, the feed-in premium (FiP) programme. Speeding up and simplifying complex licensing and permitting processes has also improved the situation for renewables. Due to the positive experience of competitive auctions and large islands becoming interconnected to the Greek mainland system, wind power could increase its contribution and help to diversify the Greek power mix, amid decreasing renewable energy source technology costs.

Figure 6.1 Renewable energy share of TPES, electricity generation, and TFC



Note: Data are provisional for 2016. The latest consumption data are from 2015.

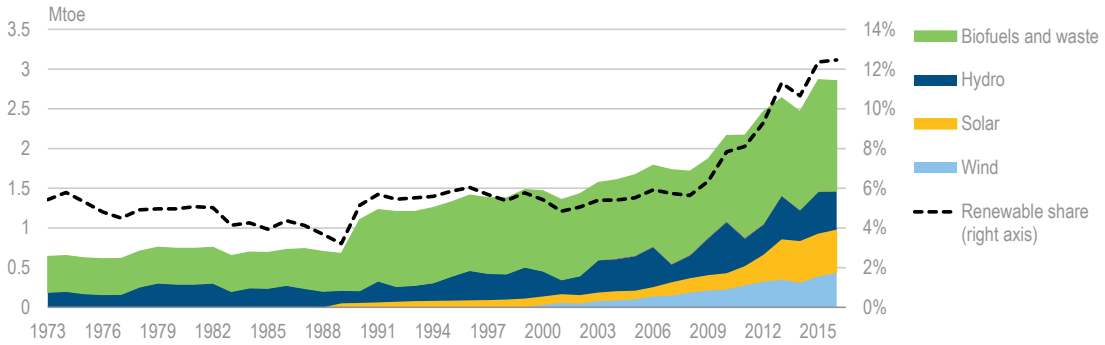
Source: IEA (2017a), *World Energy Balances 2017*, www.iea.org/statistics/.

Trends in growth of renewable energy

The share of renewables in total primary energy supply (TPES) has increased substantially in recent years, to a new peak level of 12.5% in 2016.

Biofuels (including small shares of waste) is the biggest renewable primary energy source, accounting for around half of the renewable share in TPES. The biofuel supply was 1.4 million tonnes of oil equivalent in 2016, representing an increase of 36% since 2006. Solid biofuels accounted for three-quarters of the total biofuel and waste supply in TPES, and are mainly used for heating in residential boilers (see Figure 6.2). The most significant growth has come from solar energy, which has increased nearly fivefold since 2006 and accounted for 19% of renewables in TPES in 2016. Wind power has also increased rapidly and more than tripled over the last decade. Hydropower has experienced large annual fluctuations, as the water available for power generation changes during rainy and dry years.

Figure 6.2 Renewable energy as a share of TPES, 1973-2016

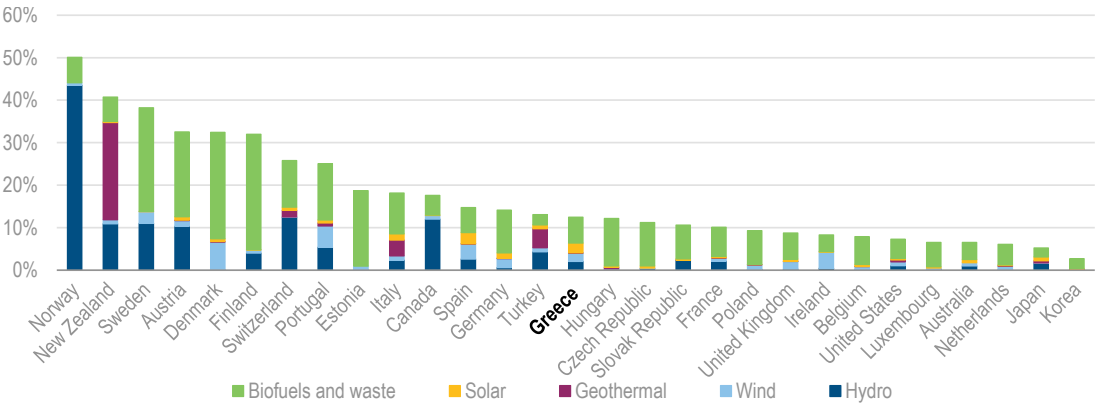


Note: Data are provisional for 2016.

Source: IEA (2017a), *World Energy Balances 2017*, www.iea.org/statistics/.

Greece has a share of renewables in TPES that is the median among IEA member countries, with 14 countries above it and 14 below it (see Figure 6.3). The share of solar in TPES is the second highest after Spain. For the other renewable energy sources, Greece is at an average level.

Figure 6.3 Renewable energy as a share of TPES in IEA member countries, 2016



Note: Data are provisional for 2016.

Source: IEA (2017a), *World Energy Balances 2017*, www.iea.org/statistics/.

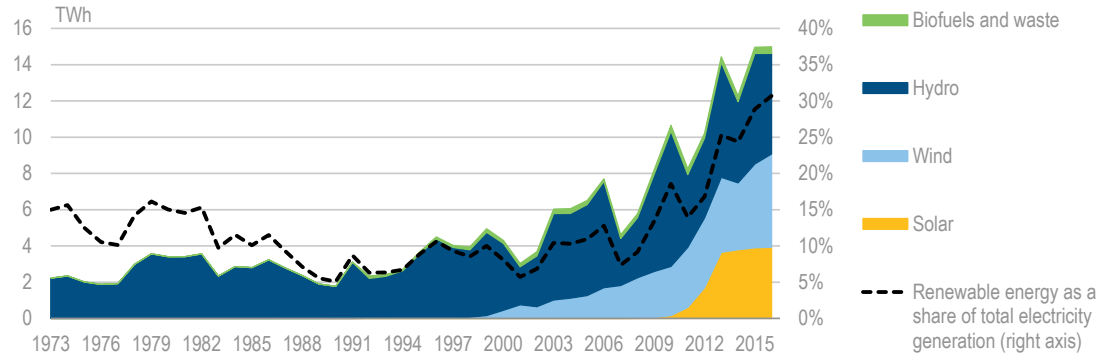
Electricity from renewable energy

Renewable energy sources reached a share of 31% of electricity generation in 2016 (see Figure 6.4). This is the result of a rapid growth in wind and solar installed capacity and the decrease in total electricity supply during the past decade. Total power generation peaked at 62.9 terawatt hours (TWh) in 2008 and has fallen by 22% since then.

Wind power generation increased from negligible levels in the late 1990s to 5.1 TWh in 2016, equal to 10.5% of the total electricity generation. Solar power has had an even more impressive growth, experiencing a nearly twenty-five-fold increase from 0.16 TWh in 2010 to 3.9 TWh in 2016. Hydro power has consistently accounted for the largest share of renewable electricity, but with substantial annual fluctuations. Hydro power production was 5.5 TWh in 2016, equal to 11.4% of the total generation. Greece also has a small share of electricity from biofuels, accounting for less than 1% of the total electricity generation.

The share of variable renewable in power generation reached 19% in 2016. While wind power has increased, the growth in solar power has slowed in recent years to more modest levels, with an 8% increase in generated solar power between 2013 and 2016 (see Figures 6.4 and 6.5).

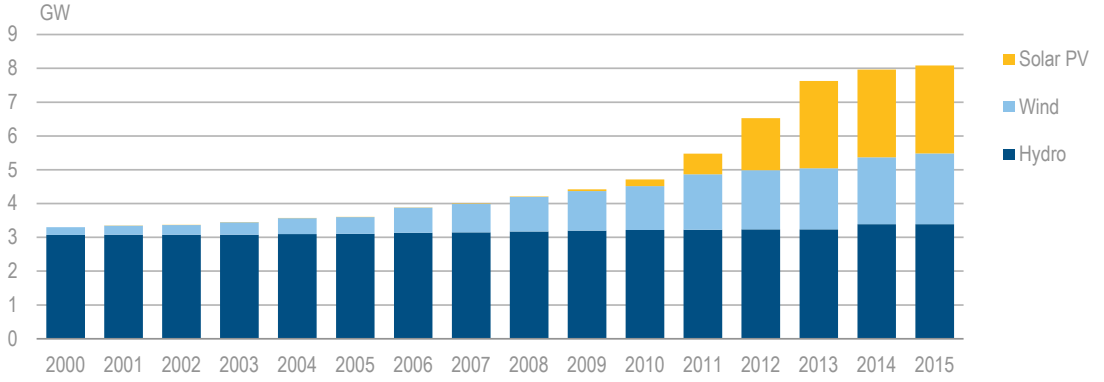
Figure 6.4 Renewable energy share of electricity generation, 1973-2016



Note: Data are provisional for 2016.

Source: IEA (2017a), *World Energy Balances 2017*, www.iea.org/statistics/.

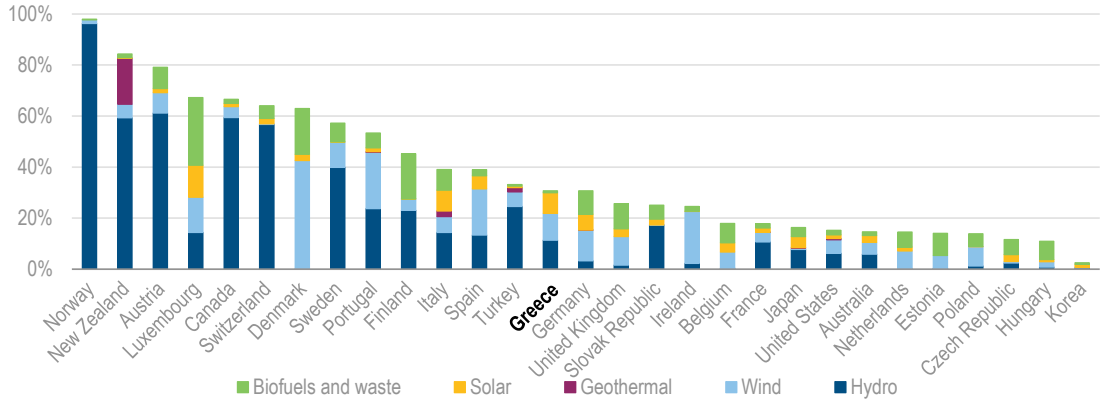
Figure 6.5 Installed capacity of hydro, wind, and solar power, 2000-15



Source: IEA (2017b), *Electricity Information 2017*, www.iea.org/statistics/.

Among IEA member countries, Greece's share of renewable electricity was near the median in 2016 (see Figure 6.6). The share of solar power in Greece's total electricity generation was the third highest in the IEA, after Luxembourg and Italy. The share of biofuels and waste, on the other hand, was the fourth lowest.

Figure 6.6 Electricity generation from renewable energy sources as a percentage of all generation in Greece and IEA member countries, 2016



Note: Data are provisional for 2016.

Source: IEA (2017a), *World Energy Balances 2017*, www.iea.org/statistics/.

Institutional framework

The Ministry of Environment and Energy is in charge of the overall policy design and legislative framework for renewable energy in Greece, across the different sectors.

The Regulatory Authority for Energy (RAE) is responsible for carrying out competitive renewable energy source auctions, ensuring time limits are kept for connection. RAE has set up a GeoPortal for all renewable energy source projects in Greece that either have been granted a production licence or have applied for a production licence.

The market operator (LAGIE) is the counterparty of renewable energy source and co-generation[9] producers for compensation (FiTs and FiPs), and the administrator of the RES and CHP registry of the interconnected systems and of the special account of RES and CHP (RES = renewable energy sources; CHP = combined heat and power).

The Independent Power Transmission System Operator (ADMIE) facilitates transmission system development and connection of renewable energy.

The Hellenic Electricity Distribution Network Operator (HEDNO) facilitates grid development and connection of renewable energy; it is the counterparty of renewable energy source producers for compensation (FiTs) and the administrator of the RES registry for the non-interconnected islands (NIIs).

The Centre for Renewable Energy Sources and Saving (CRES) supports individual projects, including research and development, analysis of renewable energy source

[9] *Co-generation* refers to the combined production of heat and power.

potentials, and scenario modelling (see Chapters 1, 5 and 7 for more details). All these entities work together closely to support the development of renewable energy in Greece.

Policies and measures on renewable energy

Greece developed its policy framework under the European Union (EU) Renewable Energy Directive (Directive 2009/28/EC), which set out an overall binding national target for Greece of 18% of renewable energy sources in gross final energy consumption for 2020. Greece chose to raise its ambitions to a 20% overall share for 2020 and set the following indicative sector targets (Law 3851/2010 and the national renewable energy action plan (NREAP)) for the contribution of renewable energy source to:

- gross final energy consumption for heating and cooling: at least 20%
- gross final electricity consumption: at least 40%
- gross final energy consumption in transportation: at least 10%.

Greece has made uneven progress across the sectors (Table 6.1). The targets for renewable heating and cooling with shares of around 26% are above 2020 expected shares, while renewable transport is lagging with 1.4% against the 10% target.

Installation targets were overachieved for solar PVs, which reached 2 600 megawatts (MW) against the targeted 2 200 MW for 2020, but wind power underachieved its target in 2015. The drivers for the deployment rate are a combination of financial, policy, and administrative barriers, which are set out in the following sections.

Table 6.1 Progress made towards EU 2020 targets (%)

	2011	2012	2013	2014	2015
Renewable energy sources – heating and cooling	20.23	24.43	26.47	26.85	25.90
Renewable energy sources – electricity	13.82	16.48	21.24	21.92	22.09
Renewable energy sources – transport	0.74	1.06	1.04	1.37	1.43
Total renewable energy sources	**11.03**	**13.83**	**14.99**	**15.32**	**15.44**

Heating and cooling

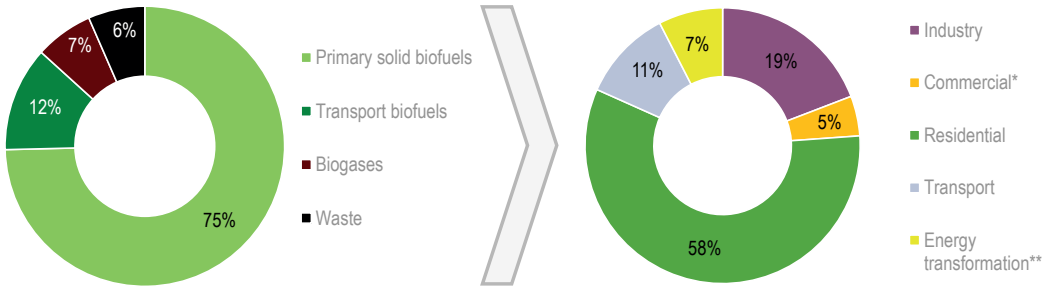
Greece has around 3 gigawatts (GW) thermal capacity of solar thermal collectors installed on residential houses and some commercial solar heating and cooling installations. However, CRES considers there is a great unexploited potential in the tertiary sector (hotels, public buildings, hospitals, and industries). Greece is a leading manufacturer of solar thermal installations, with more than 50% of the production of solar thermal installations being exported.

The condition that FiTs for rooftop PV applications are only applicable to residences that cover a part of their water heating needs by some other renewable energy source (e.g. solar thermal) has encouraged renewable energy use for heat production. This has stimulated fast and early deployment of both solar PV and solar thermal power in Greece. The new Development Law 4399/2016 provides an income tax relief for co-generation plants and

renewable energy source heating and cooling plants and also a stabilisation of the income tax coefficient.

Solid biofuels are used for heating in residential boilers, as a means to combat energy poverty. Residential consumption accounts for the largest share of biofuel demand in Greece (see Figure 6.7). Biomass from straw, olive pruning and olive kernels, cotton stalks, and wood residues is used in the food and wood industries for space and process heating (equivalent to 1.6 TWh). Greece has installed 2 MW electrical from biomass, with seven plants. CRES estimates that around 1.746 TWh remain unexploited, with a potential for carbon dioxide mitigation of approximately 460 000 tonnes. Biomass co-combustion in lignite plants and small district heating plants also present opportunities.

Figure 6.7 Supply and consumption of biofuels and waste, 2015



* *Commercial* includes commercial services and agriculture.

** *Energy transformation* includes power generation and charcoal production.

Source: IEA (2017a), *World Energy Balances 2017*, www.iea.org/statistics/.

Transport

Only a small share of biofuels is used for transport (11%), while the largest share (58%) is used by the residential sector. Biofuels accounted for 2.5% of the final energy consumption in the transport sector in 2015.

Total consumption of biofuels in the transportation sector amounted to 161 thousand tonnes in 2015, of which 23% was certified (CRES). Biofuels are mainly first-generation biodiesels produced from raw materials such as oil seeds, mainly sunflower, used cooking oils, and cottonseed (CRES). Six thousand tonnes were produced from waste and residues. There are 16 biodiesel producers (125 600 kilolitres (kL)) and six importers (6 400 kL).

Law 3851/2010 set a binding target for renewable energy sources to provide 10% of the final energy in transport by 2020. Greece issued legislation in 2016 to align the Greek biofuels sustainability certification with other EU member states. The share of certified biofuels is expected to rise significantly when all biodiesel quantities distributed in the Greek market will be verified as sustainable as of 1 October 2016 when the new system became effective.

According to the provisions of Law 3054/2002, a specific quantity of pure biodiesel is allocated to beneficiaries to achieve the 7% mandatory percentage of biodiesel blended in diesel (per volume). The allocated quantity corresponds to 85% of the biodiesel that is anticipated to be consumed throughout the year. The remaining 15% is freely marketed among refineries, wholesalers, and biodiesel producers or importers. The biodiesel

quantities are allocated every year, after a relevant call for tenders and an evaluation and allocation procedure to stakeholders.

The new investment law (4399/2016) provides investment support for the production of sustainable biofuels other than food-based biofuels and for the conversion of existing food-based biofuel plants into advanced biofuel plants in accordance with European Commission guidelines. However, biofuels that are subject to supply or blending obligations are excluded from receiving investment support.

Electricity

During 2006-15, Greece promoted electricity generation from renewable energy sources through a FiT programme, which boosted solar PV deployment in Greece. Law 3468/2006, amended by Law 3851/2010 and significantly revised by Law 4254/2014 to introduce technology and project specific criteria, initialised the programme in 2006. The 2014 law retroactively recalculated downward the FiT compensation prices for existing PVs, wind, small hydro, and co-generation installations contained in the signed power purchase agreements. The review aimed to discuss the increasing deficit that appeared in the RES special account, reflecting the high compensation paid to a significant share of existing plants. During 2012-14, Greece suspended the licensing of new PV installations because the target of 2 200 MW of installed PVs by 2020 had been achieved. Few PV systems have been installed since 2014 in a reflection of the revised lower compensation prices. Greece closed the FiT programme on 31 December 2015.

Law 4414/2016 introduced a new renewable energy source support programme in August 2016. The key objective of the law was to gradually integrate renewable energy sources and co-generation into the electricity market, with a view to the successive introduction of an electricity target model beginning in 2018. The new renewable energy source support programme has been applicable as of January 2016.

Two support forms are available:

- an FiP above the electricity market price
- a fixed price support.

The principal instrument of Law 4414/2016 is the FiP. Recognising that the electricity market is in transition, the law included several exemptions and temporary arrangements, including a fixed price support. Essentially, the law states that operating aid is paid to renewable energy source installations that enter commercial or pilot operations in the interconnected electricity transmission system and distribution network of Greece, including high-efficiency co-generation generators, as of 1 January 2016. The full implementation of the law requires ministerial decisions to provide operational details that are yet to be finalised.

The exemptions from the FiP and the requirement to participate in the electricity market are applicable for: small-scale renewable energy source power plants (below 3 MW for wind, and below 500 kilowatts (kW) for other renewable energy sources); demonstration projects; and renewable energy source power plants in NIIs. For those projects, a fixed price operating aid contract is concluded between the project operator and LAGIE, the electricity market operator for the interconnected system, or with HEDNO, the market operator for NIIs.

A special case is small wind plants (below 50 kW), for which a dedicated FiT programme has already been foreseen under Law 4203/2013 and which is expected to become effective in 2017.

According to Law 4414/2016 and as amended by Law 4467/2017, a special arrangement is foreseen for renewable energy sources and co-generation projects with a power purchase agreement signed before 31 December 2015. Those projects will receive operating aid under the FiT of the previous support programme (Law 4254/2014), provided that any such new-build projects enter into commercial or trial operation by 31 March 2019 (in the case of wind, small hydro, biomass, or biogas projects) or by 31 December 2017 for all other renewable technologies and highly efficient co-generation projects.

All other new renewable energy source power plants have to directly participate in the electricity market and have balancing responsibilities. They will receive operating aid in the form of FiPs above the electricity market price. FiPs are calculated as the difference between the revenues obtained by generators from the wholesale market price for each renewable energy source or co-generation technology and the reference value per technology used or per category of power plant.

Law 4414/2016 regulates the reference value. Contracts guarantee the operating aid for 20 years (25 years for solar thermal projects). Ministerial decisions adopted by the Minister of Environment and Energy, following a proposal from LAGIE and an opinion from RAE, have determined the form, content, and details of such new standard contracts. The only exceptions are hybrid power stations, for which the standard contract is outstanding.

For certain technologies or categories of power plants, which have yet to be determined by a ministerial decision, the reference values required to calculate the FiP must be obtained through competitive bidding processes. Therefore, Law 4447/2017 has suspended the conclusion of operating aid contracts for wind power plants with an installed capacity above 6 MW and for other renewable power plants with an installed capacity above 1 MW, until the abovementioned ministerial decisions have been issued.

The European Commission's Distributed Generation Competition State Aid SA.44666 – Greece (Decision C (2016)7272) approved the new programme, which is in line with the state aid guidelines for environmental protection and energy 2014-20. Its main aim is to render renewable support more market based, avoid over or under-compensation, and address the insufficient funds in the renewable energy source support programme and the delays in paying renewable energy source electricity and co-generation producers, thus stabilising renewable support and investor certainty. The programme was applicable as of 1 January 2016, but several implementing acts are still under development.

With regard to the balancing responsibilities for RES generators, a transitional management premium on top of the applicable renewable tariff will be provided to such generators of renewables until an intraday market is operational in Greece. The premium will compensate for the additional cost of participating in the wholesale electricity market. This premium will initially be EUR 3 per megawatt hour (MWh) for wind power plants with an installed capacity up to 10 MW and EUR 2 per MWh for all other renewable power plants (including wind power plants with an installed capacity above 10 MW). It may be reduced and eventually suspended by a ministerial decision upon the existence of a liquid intraday market (see Chapter 4 on the electricity market design). Greece plans to

introduce the target model successively, starting in 2018. The new market model includes the operation of aggregators of variable renewable electricity producers to facilitate their participation in the electricity market. A last-resort variable renewable energy aggregator will also be appointed and operated under the new market model.

Two ministerial decisions are needed to fully implement the programme. The first decision will determine the renewable energy source and co-generation power plant technologies and/or categories included in the competitive bidding process, the annual number of competitive bidding processes, and the classification of the competitive bidding processes as "technology neutral" or not. It will also determine the methodology and power-sharing procedure for participation of renewable energy source plants installed in countries within the European Economic Area, as well as any other issue relating to the planning and conduction of the competitive bidding process.

The second decision will determine the installed capacity, per renewable energy source and co-generation power plant technology and/or category, that will be auctioned through the competitive bidding processes, including plants installed in countries within the European Economic Area. The decision will also determine the minimum number of tenders per year, as well as the maximum and/or minimum allowable bid value for each competitive bidding process.. The adoption of the specific auction roadmap by ministerial decision will make developers aware of the competitive bidding processes that are scheduled for the next two years and the trajectory of total installed capacity towards 2020.

Based on a decision by RAE, an announcement shall be issued for (one or more) competitive bidding processes which will determine the participation criteria, the time limits for the construction and connection of plants, and the maximum reference value. RAE organised a pilot tender for solar PVs of 40 MW for two categories in December 2016. Nine projects were awarded in the below-1 MW category, resulting in a weighted average price of EUR 98.78 per MWh. Seven projects were awarded in the above-1 MW category, resulting in a weighted average of EUR 83.3 per MWh. The pilot tender resulted in a reduction in reference values in both categories.

Laws 4203/2013 and 4414/2016 (active from December 2015) regulate net metering for PV, small wind, biomass/biogas/bioliquids, small hydro, and co-generation plants. The two laws and a revised ministerial decision issued in 2017 also regulate virtual net metering for public or private legal entities involved in activities of public benefit, in general or for local purposes, and for farmer and agricultural enterprises. Almost 10 MW of such PV installations have become operational under these programmes.

Financing of renewable energy support

Law 4001/2011 created a special account to administer the FiT programme whose cost amounted to around EUR 1.7 billion per year in 2014 and 2015 (with a peak of EUR 2 billion in 2013), for the entire country including NIIs. However, it is important to note that this amount includes the equivalent value and revenues of the renewable energy source generation from the electricity market, amounting to an average of EUR 600 million per year. Under the old programme, there were delays of over six months in the payment of FiTs to developers, and an accumulated deficit in the special account. The new FiP programme is expected to have a net cumulative cost of

around EUR 260 million until 2020; however, market revenues (equivalent to the FiT or actual revenues for the FiP) are excluded.

Law 4414/2016 splits the RES and CHP special account into: 1) The RES and CHP Special Account of Interconnected System and Network (special account I) and 2) the RES and CHP Special Account of Non-Interconnected Islands (special account II). The law also provides for two new levies that will give additional income for the renewable energy source account, instead of burdening end consumers through an increase in the existing renewable energy source (ETMEAR) levy.

Special account I is divided into two subaccounts: the Electricity Market subaccount and the Operation Aid subaccount. Inflows into special account I are defined as electricity market revenues and operating aid revenues.

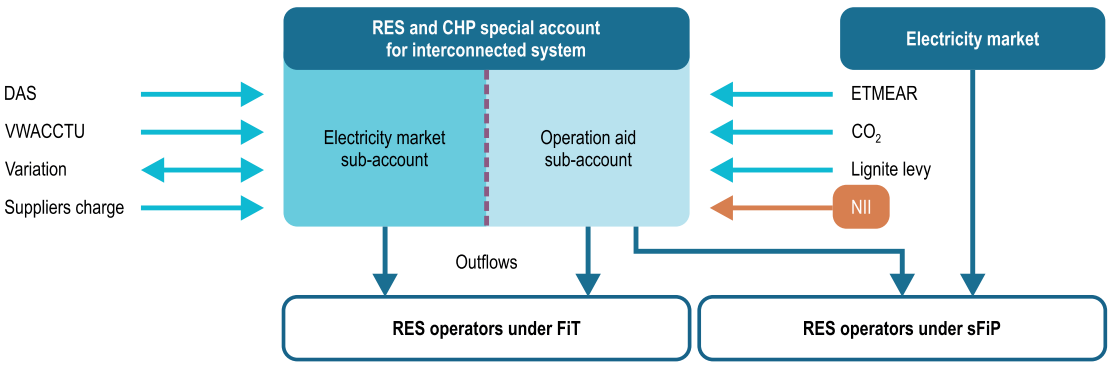
Electricity market revenues consist of four types: 1) day-ahead scheduling (DAS), 2) variation settlements, 3) variable weighted average cost of conventional thermal power plants (VWACCTU), and 4) the special charge, which electricity suppliers have had to pay starting from the last trimester of 2016.

The special charge is calculated as the difference between the applicable wholesale market price and a projection of the price that would have been in place had renewable energy electricity not been included in the wholesale electricity market. It is expected that the past deficit of the RES and CHP special account can be cleared within 2017, based on the provisions of Law 4414/2016.

For the operating aid, revenues are included from the special lignite levy of EUR 2 per MWh, the special levy for renewable energy sources (ETMEAR), greenhouse gas (GHG) emission allowances, and NII supplier payments for the production value of renewable energy sources/co-generation in the NII, based upon the average variable cost of conventional units on NIIs.

A second additional levy, which will take effect from 2018, may be imposed on suppliers by a ministerial decision following an opinion by RAE, to gradually reduce the ETMEAR levy paid by end consumers. The law also provides for the possibility to introduce a special market with guarantees of origin (see Figure 6.8).

Figure 6.8 Reform of the special account for RES and CHP



Subsidies to renewable energy source investment

Until 2013, all renewable energy source technologies except solar PVs could apply for investment subsidies. Law 4146/2013, amended by Article 68 of Law 4155/2013, limited subsidies only to investments in hydro, pumped hydro, hybrid, biomass, and biogas stations for all the investment plans submitted after 1 January 2014.

However, all renewable energy source technologies are eligible for tax incentives. According to the new development law (4399/2016), investment subsidies will be granted to small hydro plants (up to 15 MW), high-efficiency co-generation plants using renewable energy sources, hybrid renewable energy source plants in the NIIs (up to 5 MW), production of heating and cooling from renewable energy sources, and high-efficiency district heating and cooling. The revenues from the operating aid on the basis of the differential premium or the fixed price shall be depreciated for renewables plant owners that are receiving subsidies on investment, or in an equivalent form (guarantees, tax relief, etc.).

Licensing and permitting of renewable energy source projects

The Greek government is implementing a review of the environmental impact assessment (EIA) framework with the aim to reduce the number of projects requiring an EIA from 22 000 per year to around 2 000-3 000 per year and to reduce the time needed for an EIA procedure from 20 months to 5-6 months through several measures including:

- removing the preliminary assessment
- providing for predetermined environmental terms and conditions for thousands of projects
- abolishing the co-signing of environmental permitting by other ministers
- creating a centralised electronic system for submitting and managing EIAs
- outsourcing the evaluation process of EIAs to the private sector.

Greece is reforming land use and land planning. A spatial plan for renewable energy sources is already in place and planned for offshore wind parks. The fast-track legal framework will provide for immediate licensing of big investment projects. Revision of the 12 regional spatial plans is progressing.

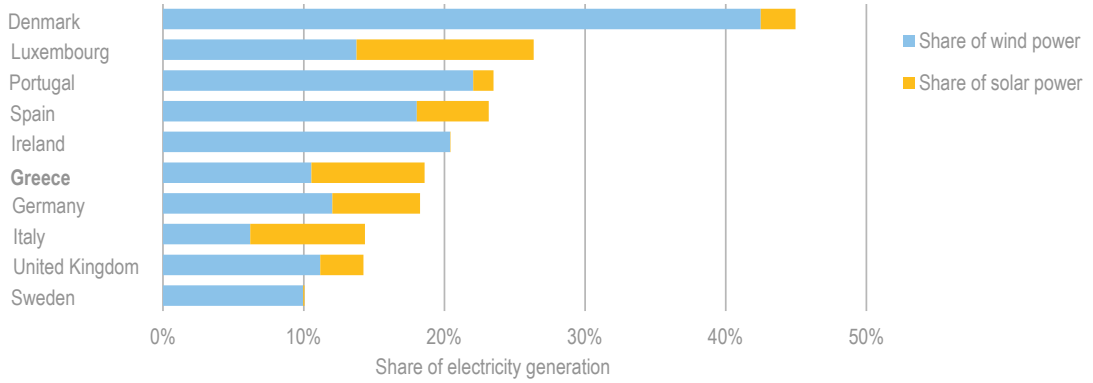
All the producers of electricity from renewable energy sources (with the exception of solar PVs) are paying a special charge equivalent to 3% of their total gross revenues. Of that, 1% goes directly to local citizens, 1.7% to the municipalities concerned, and 0.3% to the special fund for the implementation of regulatory and environmental plans.

System integration of renewable energy

Greece's renewable energy share in gross final electricity consumption reached 24.5% in 2015 compared to the NREAP target of 26%, according to data from the NREAP third progress report (2016). Greece has added over 2 GW of PV capacity to the grid since 2011, making it the country with the third-highest share of solar PVs among EU member states in 2016. The current variable renewable energy penetration levels place Greece within the top five countries among EU member states.

The renewable energy electricity mix has been significantly different from the NREAP projections, with the main share in the renewable energy installed capacity being PVs instead of wind installations. The PV sector has attracted high interest from investors due to the favourable FiT programme, reduction of PV capital expenditure, and adoption of different policy measures for streamlining of the licensing procedure (exemptions for the obligation of obtaining certain licences for smaller installations). However, the penetration of PVs remained almost stable in 2014 and 2015 due to changes in the FiT programme. The current installed capacity of renewable energy sources (excluding large hydro) in Greece is more than 5.3 GW, with 2.6 GW being PVs, 2.4 GW wind, and the rest mainly small hydro and biomass.

Figure 6.9 Variable renewable energy share of total electricity generation in EU member states (top 10), 2016



Source: IEA (2017a), *World Energy Balances 2017*, www.iea.org/statistics/.

Greece has managed to integrate high levels of renewable energy sources due to its diversified capacity mix (see Chapter 4). In addition, around 15% of internal demand is covered through regional electricity imports, and Greece also has 699 MW of pumped hydro capacity (the 315-MW Sfikia plant on the Aliakmon river and the 384-MW Thissavros plant on the Nestos river).

However, international experience has shown that shares of variable renewable energy penetration in addition to what Greece has already achieved will need to be accompanied by technical measures. To keep up with its long-term renewable energy targets while ensuring system reliability, Greece needs to gradually transform its power system to facilitate future integration of solar and wind power. Strengthening its internal transmission network, including the important step of interconnecting many NIIs with the main network, investing in flexible generation, enhancing regional interconnections, exploring the technical and economic potential of energy storage like pumped hydro, and implementing demand-response programmes are necessary steps for Greece to take.

The issue of interconnecting the Greek islands with the mainland gird is of high importance due to the geographical structure of Greece and the technical, economic, and environmental benefits of integration. Greece consists of one mainland grid and 32 non-interconnected electrical systems on the islands. Most of the high-potential renewable energy is located at or near the islands; however, there are integration challenges related to the absence of storage and the high fluctuations of electricity consumption with seasonal tourism. Around only 10% of the total installed renewable energy capacity (excluding hydro) is located on the islands because the demand is much

lower compared to mainland Greece and due to technical restrictions related to the variable nature of wind and solar power. The current maximum technically possible penetration of variable renewable energy in NIIs is around 30%. Solar and wind output is balanced using diesel generators in most NIIs.

Higher variable renewable energy penetration can be achieved through the development of hybrid systems and integration of energy storage technologies. However, the enormous solar and wind potential of Greece can be better exploited through interconnecting islands with the mainland transmission system while respecting the local environment. This will help Greece to decrease its dependence on expensive diesel fuel while greatly increasing the balancing ability of the islands, as they will become part of a larger integrated power capacity pool. In addition, the technical potential for renewable energy integration will greatly increase opening a path for a further reduction of lignite usage in the future.

ADMIE has ambitious projects for the coming decade to connect the Greek islands to the mainland system. The interconnection of some islands belonging to the Cyclades group is planned to be activated by 2017/2018 and will replace up to 7% of the current total consumption of the NIIs.

Interconnecting the island of Crete with the mainland system is also planned. Crete is the largest NII system, with a great renewable energy source potential, corresponding to nearly three-fifths of the current total NII electricity consumption. Greece is also planning to strengthen its regional interconnections, which can potentially provide additional balancing capabilities to the Greek system. These interconnection projects involve high investment costs, but can facilitate renewable energy penetration and reduction in the curtailment of wind and solar generation.

Integration of variable renewable energy has also been partly facilitated by the increasing share of natural-gas-fired technologies, which can respond quickly to short-term and seasonal fluctuations of solar and wind power. Greece's natural gas capacity share is expected to increase according to the ADMIE generation capacity adequate assessment for the period 2017-23.

In addition, Greece should assess the economic, technical, and environmental benefits of hydro towards reaching its future energy targets. The *2016 World Atlas & Industry Guide* of the *International Journal of Hydropower and Dams* estimates the economic potential of hydro in Greece to be 15 000 gigawatt hours per year, of which only one-third is exploited (AMI Hydropower Foundation, 2016).

ADMIE's generation capacity adequacy assessment for 2017-23 estimated around 250 MW of new hydro to be commissioned within the next few years; however, Greece should consider better utilisation of its hydro potential. In addition, the exploration of development of pumped hydro projects could bring operational benefits, especially at higher variable renewable energy shares.

Assessment

Since the last IEA review in 2011, Greece has had an impressive increase in the share of renewable generation despite the decrease in total generation of around 11%. An early leader in solar thermal heating, the increase in wind and solar PV generation from 2010

to 2015 amounts to almost 300%, and the share of renewable generation stood at just under 31% in 2016. This is a commendable achievement. Greece has remarkable conditions for renewable energy deployment, offering great potential. While solar PV and renewable energy source heating and cooling targets (solar heating) have been overachieved, Greece needs to progress to meet its wind power targets and renewable energy source transport targets.

Greece has put in place a legal framework for the support and future growth of renewable electricity and high-efficiency co-generation through a market-based FiP programme. Greece should avoid any repeat of the retroactive haircut applied to developers, although it was necessary to close the previous programme to deal with deficits amid decreasing technology cost. Greece is working hard to avoid long delays in putting the new programme into place. There is still a need for clarifying the rules of the competitive tenders, for the implementation of the new programme. During the transition period, until competitive auctions under the new FiP programme are fully operational, the outstanding ministerial decision should be issued and adopted without delay. This will give developers an indication of the frequency and total budget for future auctions, so they can ensure they are available and prepared to participate.

As the EU focus starts to turn towards 2030 targets, Greece should maintain its momentum and high ambitions, particularly as technology costs have come down dramatically. Renewables can strengthen the security of supply, help to encourage economic growth, and preserve the natural beauty that draws many visitors to Greece. The government may consider gradually phasing out, after 2020, the renewable energy source premium or FiT support, as technologies mature, because technology costs are decreasing and competitive auctions are likely to reduce the costs of renewable energy source support even further.

Speeding up and simplifying complex licensing and permitting processes has been part of the success in achieving the penetration of renewable generation. A detailed programme and timeline for the upcoming competitive auctions is needed under the new renewable energy source law, as well as a clear monitoring framework for the construction and connection times for new renewable energy source projects. However, complex administrative layers remain a challenge. The payment of money from developers to local communities is a key policy that should be consistently applied, to preserve and protect public support for renewables.

It is even more important that the developers of renewables projects receive timely payment of levy funds to protect investor confidence and secure future investment. The current system is characterised by considerable complexity, due to the different types and sizes of installations (NIIs, PV rooftops, etc.) and the different forms of inflows to the renewable energy source account. The new support programme provides an opportunity for producers of renewable energy source plants to participate in the electricity market and to receive part of the corresponding compensation directly by the market. The reform of the special account is commendable. However, challenges remain. Non-payment by customers and the complexity of the collection and distribution of levies is significantly delaying payments to developers and discouraging investment, and Greece should prioritise simplification.

The notable increase in solar PVs and wind, plus an increase in small hydro is diversifying the generation mix. There is potential for boosting renewable energy,

including geothermal, biomass (possibly co-firing with lignite), and concentrated solar power, and for their use in other sectors, such as industrial heat and the services sector. There are synergies for securing emissions reductions, progressing towards renewables targets, and boosting local economic growth.

Interconnection of the islands with the mainland will help to avoid the curtailment of wind and solar generation. Future grid development is likely to start with fresh capital and ambitions based on recent reforms in the power sector, notably the separation of network operation and ownership. Interconnections and options for storage and hybrid plants can ensure that Greece maximises the benefits of cheap renewable power. Current network ownership changes, and market and regulatory signals from the new programme of competitive auctions, are likely to bring good geographic diversity of variable renewable energy capacity. Problems surrounding grid integration in Greece are mainly linked to isolated non-interconnected systems, where wind needs to be curtailed at times when the electricity load is low.

As other EU member states progress in de-carbonising, the transport sector remains challenging. Greece has a biodiesel blending mandate, but without new measures, the country cannot increase contributions towards the target for 2020. Notably, a strategy for penetration of biofuels is needed to achieve the 10% target. Greece imports mainly first-generation biodiesels, but this will be a challenge under future EU rules, which aim to limit contributions from such biofuels. No blending mandate is in place for gasoline. The share of renewable energy sources stood at 1.43% in 2015. Blending of bioethanol in gasoline is considered essential to meet the 2020 targets. An amendment of Law 3054/2002 to promote the penetration of bioethanol as a blending component in gasoline is expected to be published in 2017.

There is almost no deployment of electric or hydrogen vehicles or of natural gas buses. Public transport became an economic alternative to passenger transport during the financial and economic crisis, as fuel taxes rose. Alternative fuel infrastructures would increase the competition in the oil retail market and promote GHG emissions reductions in transport.

Recommendations

The government of Greece should:

- Implement a long-term, stable, and market-based policy framework for renewable energy support, with simplified administrative one-shop procedures and a roadmap for future competitive auctions to 2020.
- Actively pursue interconnection of NIIs with the mainland transmission system to use their strong renewable energy potential to achieve multiple energy policy objectives, including meeting environmental and climate goals by reducing oil-fired power generation and enhancing energy security.
- Implement a streamlined process for the collection and distribution of levies for renewable energy source support programmes and other public service obligations.

- ☐ Fully explore the potential for sustainable biomass for generation (possibly co-firing with lignite) and in other sectors, such as industrial heat and transport (biofuels).
- ☐ Evaluate cost-effective options for clean transport, including actions that integrate renewable fuels and energy efficiency, and consider public transport, modal shifts, and behavioural changes.

References

IEA (International Energy Agency) (2017a), *World Energy Balances 2017*, OECD/IEA, Paris, www.iea.org/statistics/.

IEA (2017b), *Electricity Information 2017*, OECD/IEA, Paris, www.iea.org/statistics/.

International Journal of Hydropower and Dams (2016), *2016 World Atlas & Industry Guide*

7. Focus area 2: Energy efficiency

Key data

(2015)

Energy consumption per capita (TFC per cap): 1.5 toe (IEA average 3.1 toe), -20% since 2005

Energy intensity (TFC per GDP PPP): 64 toe per USD million PPP (IEA average: 78), -2% since 2005

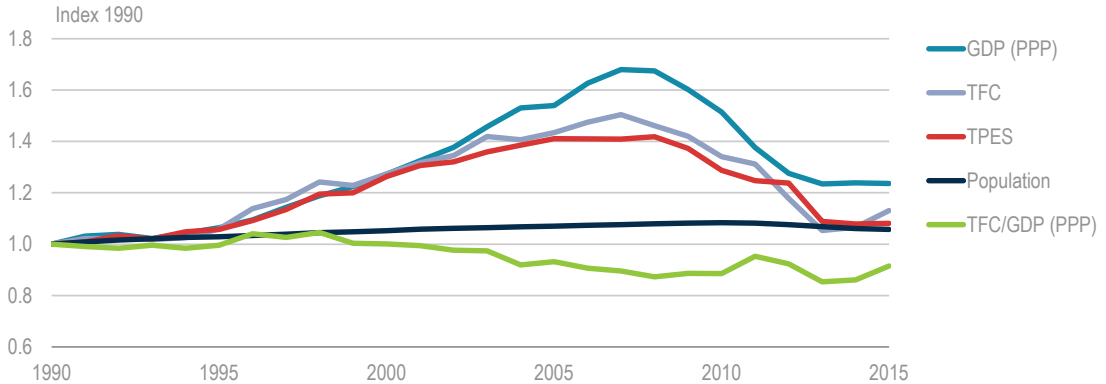
TFC: 16.4 Mtoe (oil 54.5%, electricity 26.7%, natural gas 8.0%, biofuels and waste 7.9%, coal 1.4%, solar 1.2%, heat 0.3%, geothermal 0.1%), -21% since 2005

Consumption by sector: Industry 23.4%, residential 26.9%, transport 35.1%, commercial and public services including agriculture, forestry, and fishing 14.6%

Overview

Energy consumption in Greece has fallen significantly following the economic and financial crisis in 2008. After an extended period of steady increase, gross domestic product (GDP) (in terms of purchasing power parity) fell by 26% between 2008 and 2015, contributing to a 28% reduction in total final consumption (TFC) such that it is now at the lowest level in almost two decades. Greece observed decoupling of energy use and GDP growth in the early 2000s, leading to a decrease in energy intensity, which remains below the 1990 level, despite recent increases as shown in Figure 7.1.

Figure 7.1 Energy consumption and intensity, 1990-2015



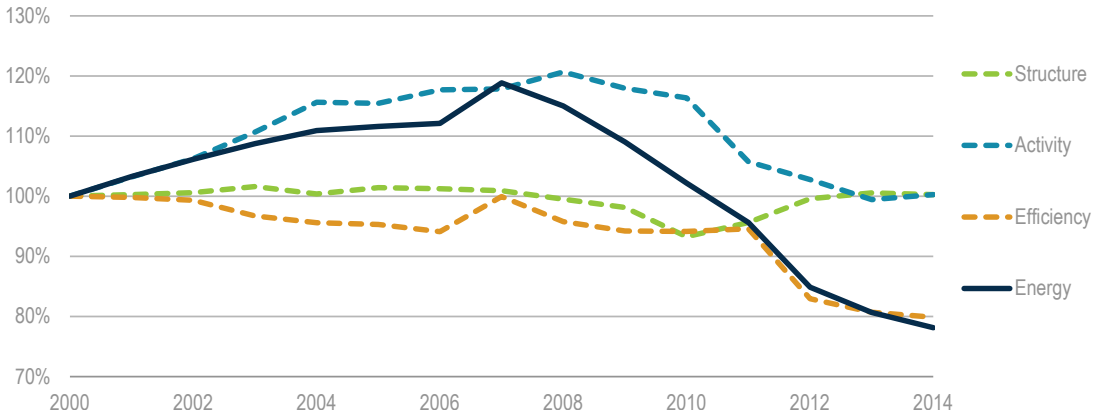
Source: IEA (2017a), *World Energy Balances 2017*, www.iea.org/statistics/.

Notes: PPP = purchasing power parity; TPES = total primary energy supply.

A decomposition analysis of TFC is presented in Figure 7.2, to provide a detailed understanding of changes in energy use in Greece. Decomposition analysis involves the splitting of energy consumption into three main factors:

- activity factors, which relate to the level of activity creating demand for energy within the economy
- structural factors, which reflect the mix of energy-consuming activities within various sectors of the economy
- efficiency factors, which reflect the energy used per unit of activity, such as the energy use per unit of industry sector gross value added or building energy consumption per unit of floor area.

Figure 7.2 Final energy consumption, 2000-14



Source: IEA (2017b forthcoming), *Energy Efficiency Indicators 2017*, www.iea.org/statistics/.

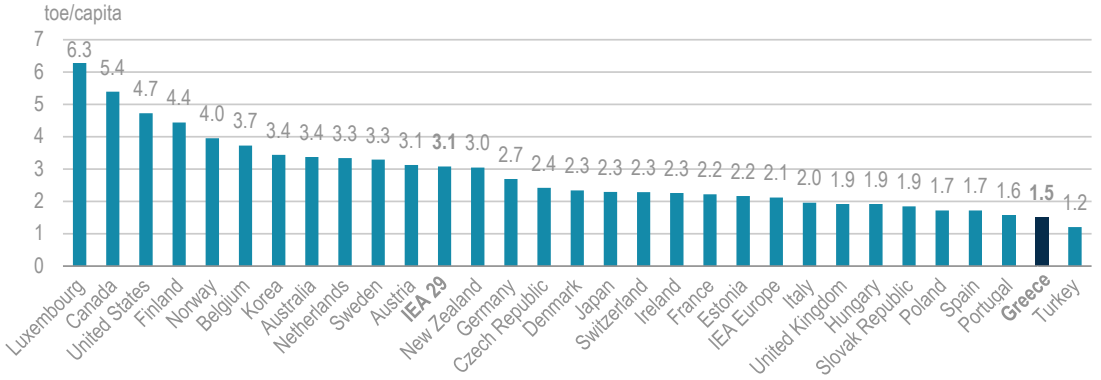
Decreasing levels of activity following the economic and financial crisis, as evidenced by the marked declines in the activity effect in Figure 7.2, have been the major influence on TFC in Greece. Structural effects have had a minimal influence since 2000, with improvements in energy efficiency, as illustrated by a reduction in the efficiency effect, providing some contribution to the reduction in TFC.

Energy intensity

Greece has the second-lowest TFC per capita among IEA member countries (see Figure 7.3), less than half the IEA average. However, energy intensity at the level of the whole economy is only 18% below the IEA average and higher than the average for European IEA member economies (see Figure 7.4).

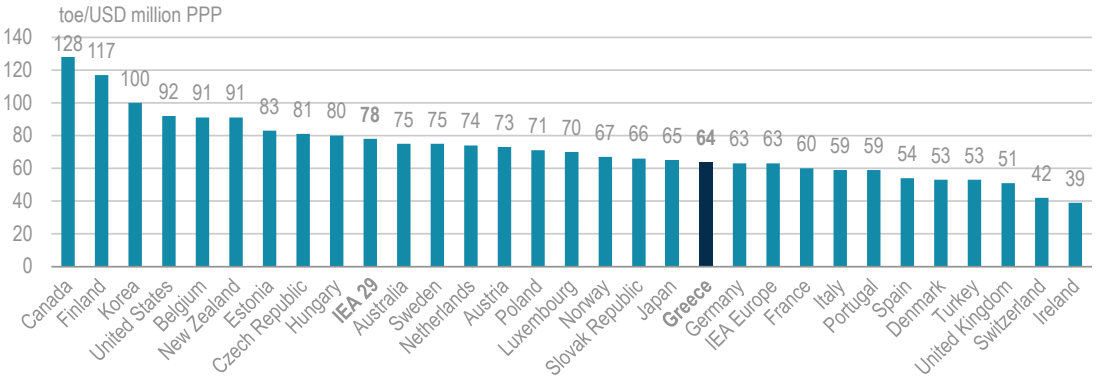
Although energy intensity in Greece is below the IEA average and comparable to other European countries, the observed trend since 1990 is a minimal improvement at a whole-of-economy level, compared to a broader decreasing trend in other IEA member economies (see Figure 7.5).

Figure 7.3 TFC per capita in IEA member countries, 2015



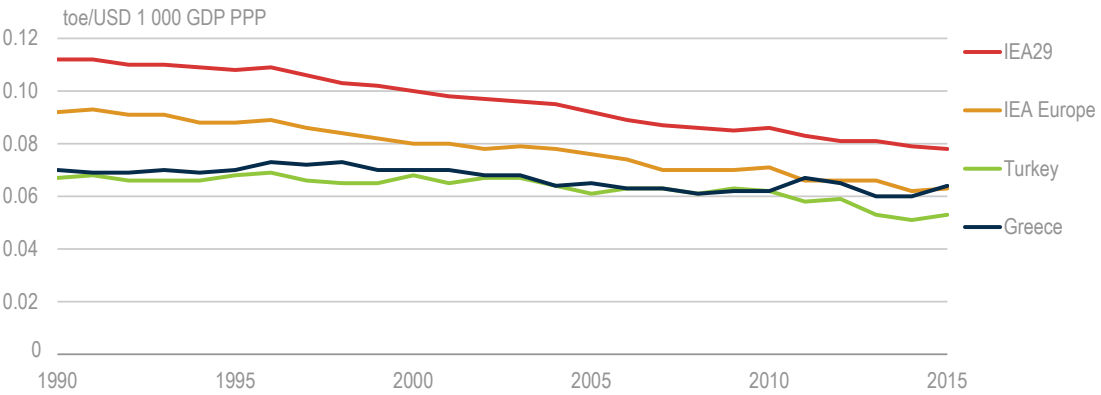
Source: IEA (2017a), *World Energy Balances 2017*, www.iea.org/statistics/.

Figure 7.4 TFC in IEA member countries, 2015



Source: IEA (2017a), *World Energy Balances 2017*, www.iea.org/statistics/.

Figure 7.5 TFC per GDP trends in Greece and in other selected IEA member countries, 1990-2015



Source: IEA (2017a), *World Energy Balances 2017*, www.iea.org/statistics/.

Policies and institutions

Energy efficiency, policy development, and implementation are the responsibilities of the Ministry of Environment and Energy. The Centre for Renewable Energy Sources and Saving (CRES), whose mandate extends to energy efficiency, provides technical

analysis and modelling services in support of policy development. This modelling has informed the Greek Government on its setting of energy efficiency targets, policy development, and assessment.

As a member of the European Union, Greece was required to set a TFC target for 2020 in compliance with the European Union (EU) 2012 Energy Efficiency Directive. This target established the basis for energy efficiency policies and measures across the Greek economy. The target set by Greece was 18.4 million tonnes of oil equivalent (Mtoe), which represented a 12% reduction on energy consumption levels in 2005. However, due to the financial and economic crisis, TFC fell to 16.4 Mtoe in 2015, 11% below the 2020 reduction target. It is unlikely that energy use in Greece will increase to a point where it will not be able meet its 2020 target, even under optimistic economic growth forecasts.

A key component of Greece's compliance with the Energy Efficiency Directive is Article 7, in which EU member states are required to ensure that energy savings of 1.5% per year are achieved by energy suppliers and distributors due to the implementation of targeted policy measures. Greece has to achieve cumulative energy savings of 3 332.7 thousand tonnes of oil equivalent (ktoe) by 2020 through the implementation of energy efficiency policy measures, as part of its compliance with the above article. These savings are separate to the economy-wide TFC target, and it is therefore possible for Greece to meet its overall TFC target but fail to comply with obligations under Article 7 of the Energy Efficiency Directive.

Implemented policy measures have not provided energy savings in line with initial expectations, due to the financial and economic crisis, low public awareness, insufficient data, and lack of funding. This has created a need for Greece to achieve larger savings between now and 2020 to comply with Article 7 of the directive. Therefore, in January 2017, informed by modelling and analysis from CRES, Greece implemented an energy efficiency obligation programme, which aims to provide 10% (332.7 ktoe) of the required energy savings by 2020. The programme requires energy suppliers to obtain savings in line with an annual target, which is identified based on the market share of the obligated entity.

Transport

Energy consumption

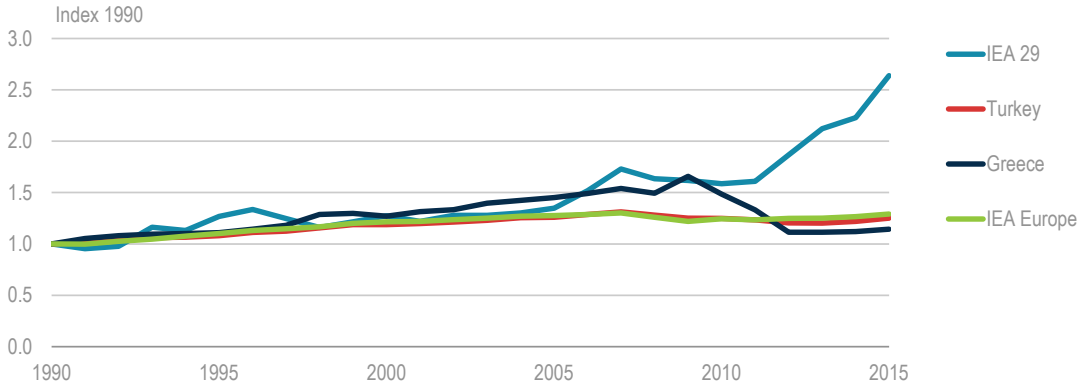
The transport sector is responsible for the largest share of TFC in Greece, consuming 5.8 Mtoe in 2015 (35% of TFC). Transport energy consumption peaked in 2009 at 8.4 Mtoe, but fell by one-third in the three years to 2012, and has been stable since then (Figure 7.6). This is a similar trend to other countries in the region and Europe, but it is contrary to the overall trend within IEA member countries.

Oil accounts for 97% of the transport sector energy use, with the remainder comprising biofuels (2.5%) and small shares of natural gas and electricity. Motor gasoline and diesel are the most common oil fuels, representing 45% and 39% of the total oil consumption, respectively.

Road transport accounted for 88% of the total transport energy consumption in 2014. The rest consisted of sea transport (8%) and small shares of domestic aviation and rail

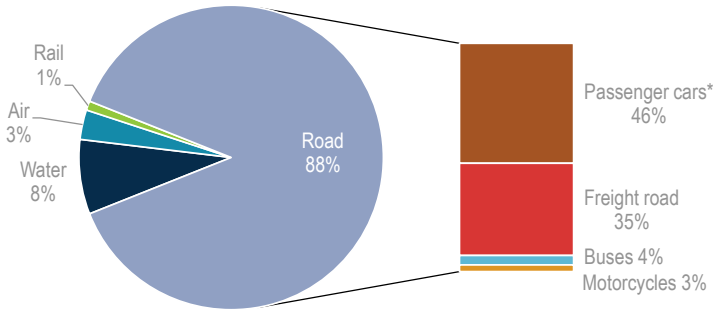
transport. International aviation was not counted in the TFC statistics. Passenger vehicles accounted for over half of the energy consumption within road transport, with freight transport responsible for most of the remaining energy use (Figure 7.7).

Figure 7.6 TFC for the transport sector, in Greece and in other IEA selected member countries, 1990-2015



Source: IEA (2017a), *World Energy Balances 2017*, www.iea.org/statistics/.

Figure 7.7 Energy consumption by means of transport, 2014



* *Passenger cars* includes cars, sport utility vehicles, and personal trucks.

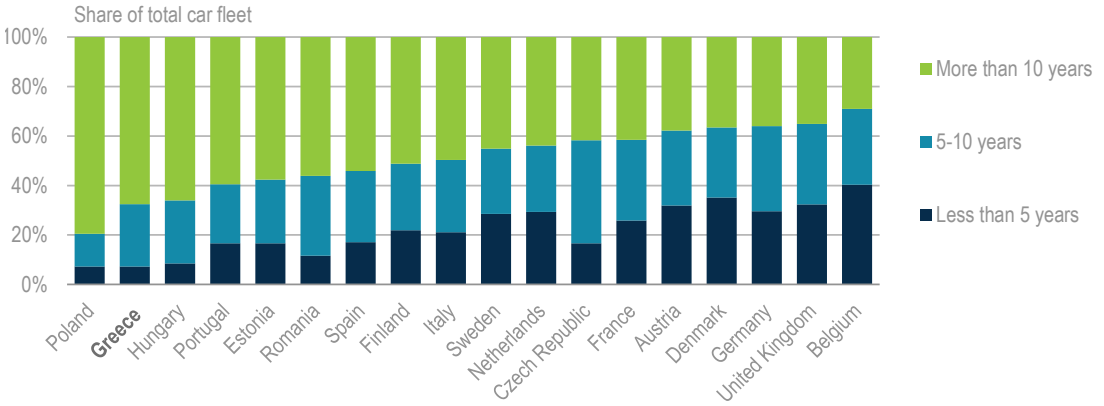
Source: IEA (2017b forthcoming), *Energy Efficiency Indicators 2017*, www.iea.org/statistics/.

Energy intensity

The energy intensity of the Greek transport sector is influenced by the usage patterns and age of vehicles. Figure 7.8 shows that Greece had the second-highest percentage of passenger vehicles aged over ten years within Europe, in 2014. However, due to its ongoing compliance with European vehicle fuel efficiency standards coupled with changing use patterns following the economic and financial crisis, the energy intensity of the various modes of passenger transport has reduced since 2000 (Figure 7.9). Overall, energy intensity in passenger transport decreased by 41% between 2000 and 2014.

Although there was a 52% reduction in activity for freight transport (tonne kilometres) between 2000 and 2013, there was only a 9% reduction in energy use. This resulted in a worsening in the energy intensity and is likely a reflection of the age of road freight vehicles in Greece. The energy intensity for freight transport increased by 43% between 2000 and 2014.

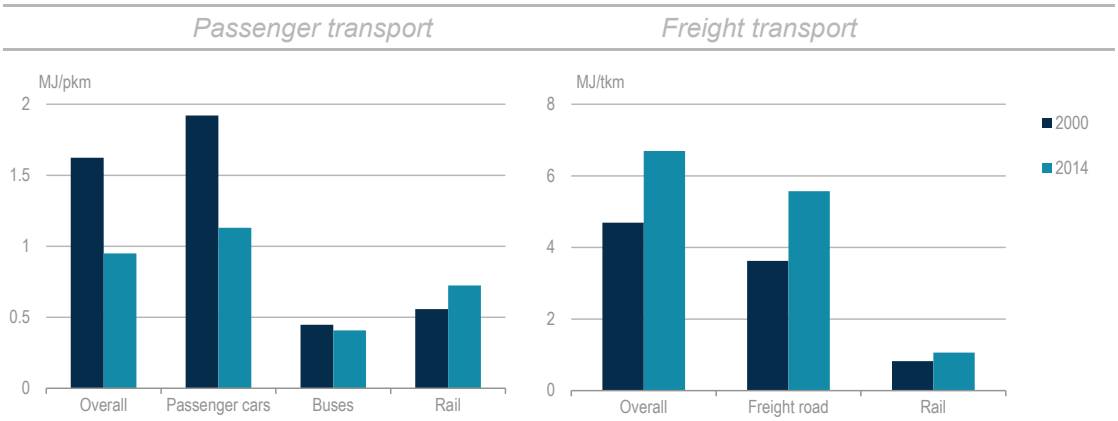
Figure 7.8 Age of the passenger car fleet in selected European countries, 2014



Note: Data not available for all countries.

Source: ACEA (2016b), *Average Vehicle Age 2016*, http://www.acea.be/statistics/article/average-vehicle-age.

Figure 7.9 Energy intensity in the transport sector by means of transport, 2000 and 2014



Source: IEA (2017b forthcoming), *Energy Efficiency Indicators 2017*, www.iea.org/statistics/.

Policies and measures

Greece's ongoing compliance with European vehicle fuel efficiency standards is the main regulatory driver for the fuel efficiency of passenger vehicles. Measures have also been implemented to incentivise the replacement of old private passenger vehicles, with 288 626 passenger vehicles being replaced between 2011 and 2016.

Greece's newly introduced energy efficiency obligation programme also extends to cover oil suppliers and subsequently the transport sector. This is an approach that has not been adopted by many other countries with similar obligation programmes, due to the limited relationship that oil suppliers have with end users, particularly owners of passenger vehicles who may source fuel from different suppliers depending on location and time. It is uncertain whether Greece could meet the targets of the obligation programme without including transport and oil suppliers, due to the energy use associated with transportation. However, it is necessary for Greece to recognise the different circumstances for oil suppliers and therefore work to ensure that the sector is supported to comply with its obligations.

Greece has implemented measures to incentivise the replacement of old, light trucks, with 14 777 light trucks being replaced between 2011 and 2016, in recognition of the worsening energy intensity of freight transport and the current lack of freight vehicle fuel efficiency standards in Europe.

Energy savings in the transport sector have also resulted from ongoing reductions in activity following the economic and financial crisis, which has contributed to a shift from passenger vehicles to public transport, supported by new infrastructure and eco-driving training programmes.

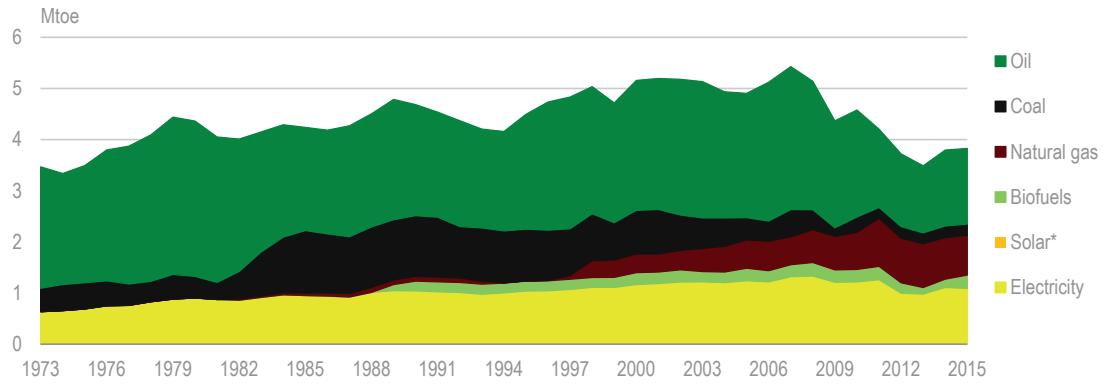
Industry

Energy consumption and intensity

The industry sector consumed 3.8 Mtoe in 2015, accounting for almost one-quarter of the overall TFC. Industry TFC peaked in 2007 at 5.4 Mtoe, but has since decreased by 29% (see Figure 7.10), primarily due to reduced activity because of the economic and financial crisis.

Oil is the largest energy source, accounting for 39% of industry TFC, followed by electricity at 28%, and natural gas at 20%. Oil products are used as an energy source and as feedstock in industrial processes. Non-energy use accounts for one-quarter of the total oil consumption in industry.

Figure 7.10 TFC in industry by source, 1973-2015



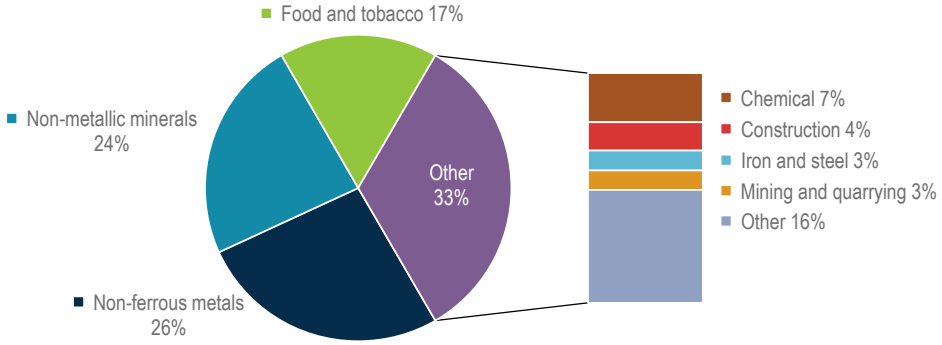
* Negligible

Note: The chart includes non-energy consumption.

Source: IEA (2017a), *World Energy Balances 2017*, www.iea.org/statistics/.

The largest energy-consuming industry subsectors are non-ferrous metals manufacturing (specifically primary aluminium production), non-metallic minerals (specifically cement manufacturing), and the food, beverage, and tobacco manufacturing industry, which together account for two-thirds of the total industrial energy consumption (see Figure 7.11).

Figure 7.11 TFC in industry by sector, 2015

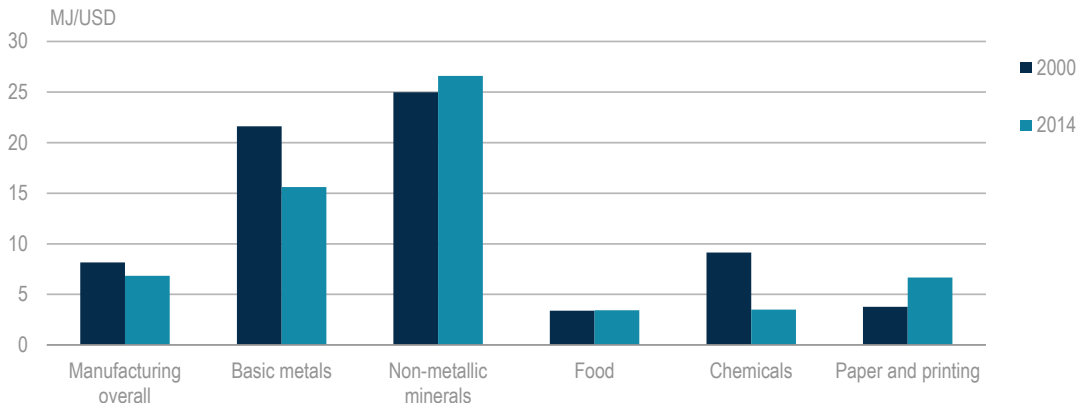


Source: IEA (2017a), *World Energy Balances 2017*, www.iea.org/statistics/.

Energy intensity has decreased in several industry subsectors since 2000, particularly in the basic metals and chemicals manufacturing sectors (see Figure 7.12). These declines are representative of ongoing technology and efficiency improvements, as well as reduced activity following the economic and financial crisis. Energy intensity in other industry sectors, such as paper and printing, increased over the period between 2000 and 2014.

These results are a reflection of the small size of some industry subsectors in Greece and the effects from the economic and financial crisis, which has limited the ability of smaller firms to invest in energy efficiency improvements. The substantial increase in energy intensity may also be a reflection of declines in resource quality, which affects the energy intensity of mining operations, in the case of the mining sector.

Figure 7.12 Energy intensity in industry in selected sectors, 2000 and 2014



Source: IEA (2017b forthcoming), *Energy Efficiency Indicators 2017*, www.iea.org/statistics/.

Policies and measures

There have not been extensive energy efficiency policies covering industry in Greece prior to 2016. However, in compliance with Article 8 of the EU Energy Efficiency Directive, Greece implemented in December 2016 a requirement for large industry to either conduct an energy audit every four years, or implement an energy or environmental management system. Small to medium-sized enterprises will also have access to quality energy audits due to these policies.

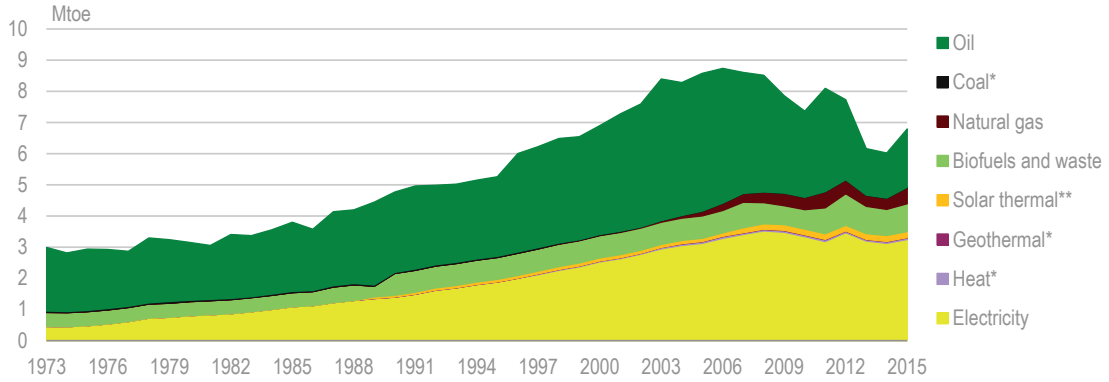
Energy efficiency opportunities identified and implemented within Greek industry can also contribute towards the obligations of energy suppliers and retailers under the recently introduced obligation programme. This represents a source of energy savings that could be exploited by parties obligated by the programme to meet legislated requirements. It is therefore of benefit to maximise the relationships among industrial energy users and energy retailers to provide mutually beneficial updates for the energy audits and obligation programme participants.

Buildings

Energy consumption and intensity

The buildings sector in Greece accounts for 41% of TFC, the majority of which is in the residential sector. TFC decreased by around 20% between 2005 and 2015 (see Figure 7.13), which is similar to the other sectors. Electricity was responsible for the largest share of TFC within the building sector, accounting for 48%. Oil was the second-largest source, representing 28% of TFC, biofuels were responsible for 13%, and natural gas for 8%.

Figure 7.13 TFC in residential and commercial sectors by source, 1973-2015



* Negligible.

** Solar thermal only. Electricity generation from rooftop photovoltaic installations is not included.

Note: The commercial sector includes commercial and public services, agriculture, forestry, and fishing.

Source: IEA (2017a), *World Energy Balances 2017*, www.iea.org/statistics/.

The large contribution of oil and biofuels is reflective of the use of inefficient oil and other biomass boilers for space heating. Although gas consumption has tripled in the last decade, its small contribution to overall buildings sector TFC reflects the limited take-up of gas-fired heating systems in Greece.

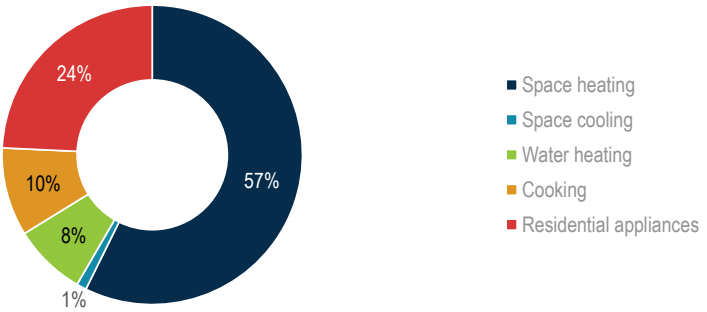
Space heating accounts for the majority (57%) of TFC in the residential sector (see Figure 7.14). The energy intensity of residential space heating dropped by 44% between 2000 and 2014. This reflects, in part, the movement away from inefficient oil heaters, but more the impact of rising fuel prices and the economic and financial crisis, which forced lower-income households to reduce the use of heating or to shift to low-cost alternatives.

These changes have resulted in a reduction in oil consumption (as shown in Figure 7.13), but not the same level of increase in gas consumption, reflecting the low take-up of alternative and more-efficient gas-fired technologies. Biomass presents a

lower-cost alternative, which has been used by some households in Greece for space heating. However, the availability of suitable biomass is limited, and therefore other forms of locally sourced biomass may be used. The combustion of these may result in the production of particulate matter and other pollutants, posing environmental and health risks.

Gas-fired condensation boilers or electric heat pumps present two alternative space heating technologies that could improve end-use efficiency within the residential sector. Information barriers (creating uncertainties around new technology), limited capital to cover the purchase and installation costs, and insufficient infrastructure (particularly gas infrastructure to support deployment) have hindered the ability for these technologies to penetrate the residential market.

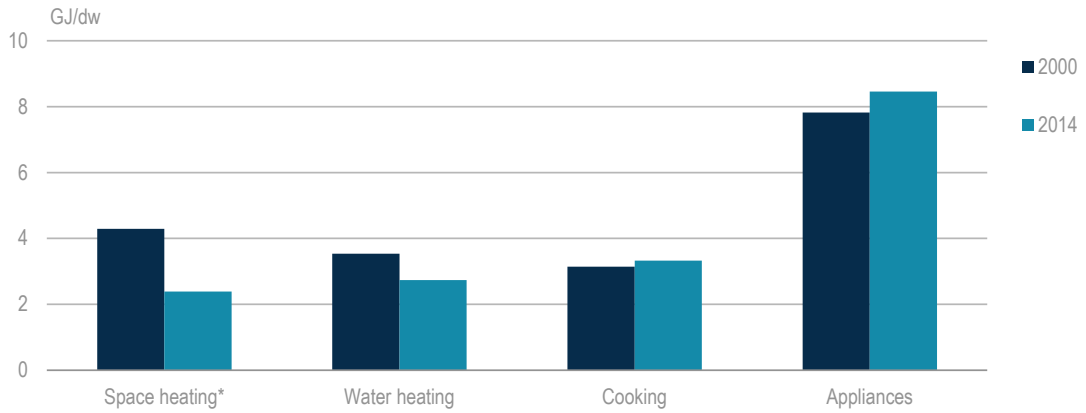
Figure 7.14 Energy consumption in the residential sector by energy use, 2014



Source: IEA (2017b forthcoming), *Energy Efficiency Indicators 2017*, www.iea.org/statistics/.

Although Greece benefits from ongoing compliance with the European Commission's eco-design and energy labelling requirements, Figure 7.15 shows that the energy intensity of residential appliances increased between 2000 and 2014. This is likely a result of low appliance stock turnover in Greece, reflecting a reduced desire and ability for Greek households to purchase new, more-efficient appliances. Such low turnover reduces the scope of a potential positive impact of European performance standards.

Figure 7.15 Energy intensity in the residential sector by energy use, 2000 and 2014



* Space heating measured in gigajoules per ten square metres.

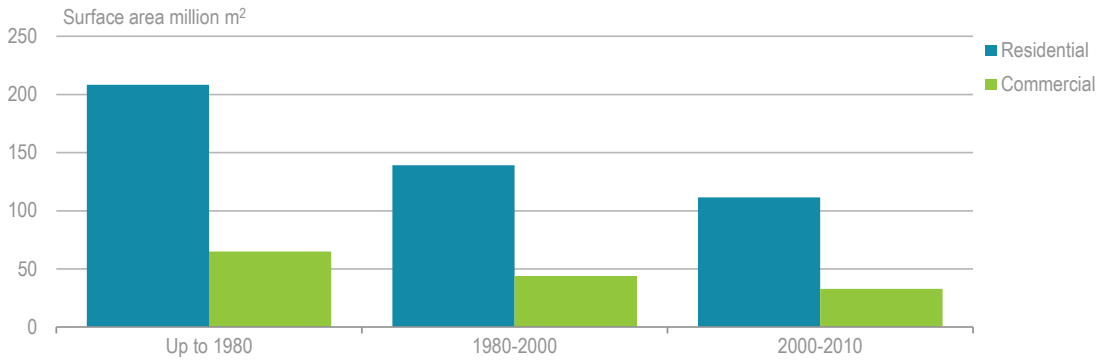
Source: IEA (2017b forthcoming), *Energy Efficiency Indicators 2017*, www.iea.org/statistics/.

Building stock

A major influencing factor on the energy use and efficiency of the buildings sector in Greece is the age of building stock. Figure 7.16 shows that 55% of residential buildings and 70% of commercial buildings were constructed prior to 1980, and therefore have no or low levels of thermal protection.

There has not been much new construction since 2010, although Greece complies with the EU Energy Performance in Buildings Directive. This means that the benefits from improved efficiency standards have not been wide reaching within the buildings sector, which is a similar outcome to that of residential appliances. The low levels of thermal insulation in older buildings, coupled with the ongoing presence of oil heaters, represent substantial sources of inefficiency within Greece's buildings sector.

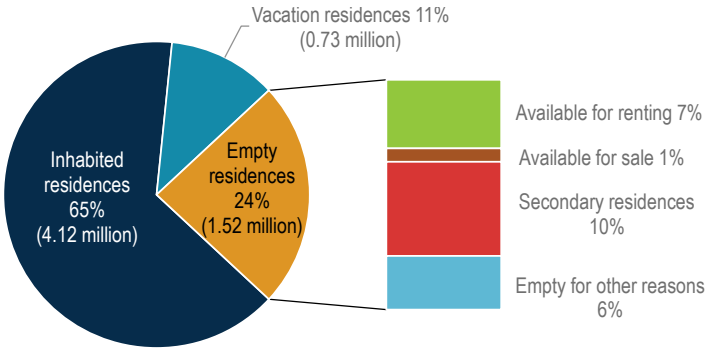
Figure 7.16 Age of building stock per residential and commercial buildings



Source: EC (2014), *Report on Long-term Strategy for Mobilising Investment in the Renovation of the National Stock of Residential and Commercial Buildings, Both Public and Private*, https://ec.europa.eu/energy/sites/ener/files/documents/GreekReportBuildingsArticle4_en.pdf.

Another factor influencing the energy efficiency of Greece's residential building stock is the occupancy rate. Figure 7.17 shows that 35% of Greece's residential buildings are either empty or only occupied on a seasonal basis (during vacations). The return on investment for energy efficiency measures is reduced in residential buildings that are either unoccupied or only occupied during certain periods of the year. Therefore, there may be less motivation for owners to improve the energy efficiency of their second or vacation residence, exacerbating low levels of efficiency within Greece's building stock.

Figure 7.17 Occupancy rate of residential buildings, 2011



Source: EC (2014), *Report on Long-term Strategy for Mobilising Investment in the Renovation of the National Stock of Residential and Commercial Buildings, Both Public and Private*, https://ec.europa.eu/energy/sites/ener/files/documents/GreekReportBuildingsArticle4_en.pdf.

Policies and measures

The primary policy measures that affect the energy efficiency of Greece's building stock have been established through its compliance with the EU Energy Efficiency Directive and the Energy Performance of Buildings Directive. Measures include mandatory efficiency requirements for public buildings and minimum requirements for energy efficiency in new and existing buildings.

Greece has also sought to overcome ongoing information barriers and limited access to finance, which have hindered the ability of homeowners to implement energy efficiency measures. For example, Greece has implemented the Save Energy at Home Programme and the Save Programme for Local Authorities in 2010. These measures have combined bank loans with government financial assistance, to cover the costs of energy efficiency measures. For these programmes, the requirement for applicants to receive pre-approval for a bank loan before applying for government funding added to processing delays and a gap between the number of applicants (over 250 000) and loan agreements (around 51 000).

Assessment

Greece has implemented some energy efficiency policies since the last review, the majority of which are due to the transposition into Greek law of requirements from the European Commission's Energy Efficiency Directive. The most notable policy is the recently implemented energy efficiency obligation programme, which is designed to assist Greece in achieving its energy savings targets in accordance with the directive.

The implementation of the obligation programme will benefit from international experience with similar policy measures. However, there are significant challenges. The short time within which the programme is required to provide energy savings (three years) requires a rapid scaling-up of energy efficiency. Greece has included the transport sector in the programme, due to the large consumption associated with transport (36.5% of TFC in 2014). This runs contrary to programmes in other countries or regions where only electricity consumption is covered. Barriers relating to access to finance still exist; these have historically limited the development of a domestic market for energy service companies to provide energy savings.

The recent implementation of the energy audit policy is a step forwards for industrial energy efficiency in Greece. Although implementation of the audit policy comes several years after other European countries, there are synergies with the introduction of the obligation programme, because savings identified and implemented through these audits can count against obligation programme targets. These synergies present an opportunity for energy suppliers to work with industry to undertake energy audits and to identify and implement efficiency opportunities.

The implementation of the energy audit policy, which also includes a reporting obligation, will provide authorities with substantial new data relating to industrial energy efficiency. Greece should maximise the value of these data by using them to provide prospective investors with an understanding of the country's energy efficiency market. The data should also be used to inform the development of future industrial energy efficiency policies.

There remains significant potential to improve the efficiency of Greece's building stock, as the effectiveness of building energy efficiency measures implemented in Greece has been hindered, due in part to the limited new construction since 2010. Efficiency measures, such as improvements to thermal insulation and replacement of oil heaters, will create multiple economic and social benefits, including the following:

- opportunities for the development of a domestic energy service company industry
- increase in the domestic gas market due to potential fuel switching
- improved living conditions linked with affordable access to energy services
- increase in the likelihood of on-time payment of electricity bills, due to a reduction in the cost of energy services.

The large percentage of building stock in Greece that is either unoccupied or temporarily occupied presents challenges. However, the high rate of building ownership also presents opportunities as barriers to renovation that result from split incentives, where the capital cost is paid by one party but the benefit obtained by another, are reduced.

There are ongoing information and financial barriers affecting prospects for improving the energy efficiency of buildings in Greece. Sustained effort is therefore required to reduce negative perceptions about new technology and to increase access to finance (loans and subsidies) that will increase the rate of energy efficiency retrofits.

Future development of energy efficiency policy measures in Greece will be influenced by compliance with new EU obligations for 2030. Greece should not use the reduction in energy use following the financial and economic crisis as an excuse for limiting energy efficiency measures, as energy use reductions have masked minimal improvements in energy intensity since 2000, due to low take-up of efficient products and low levels of efficiency within Greece's old building stock.

Greece should consider how it can be proactive by drawing on the evaluation and lessons learned from the implementation of past and current measures to shape policies suited to its circumstances and to take direct action where cost-effective benefits can be obtained.

Recommendations

The government of Greece should:

- ☐ Continue to pursue implementation of ambitious energy efficiency policies, drawing upon evaluation of outcomes from past and current measures.
- ☐ Capitalise on the synergies between the recent implementation of the energy efficiency obligation programme and energy audits policy, by encouraging greater linkages among energy suppliers and industry end users.
- ☐ Enhance its focus on improving the efficiency of existing buildings by developing targeted policy measures that aim to reduce financial and information barriers.

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ANNEX A: Organisation of the review

Review criteria

The Shared Goals, which were adopted by the IEA Ministers at their 4 June 1993 meeting in Paris, provide the evaluation criteria for the in-depth reviews conducted by the IEA. The Shared Goals are presented in Annex C.

Review team

The review team visited Greece from 2 to 7 April 2017. During the visit, the review team met with government officials, representatives from ministries and government agencies, market participants, non-governmental organisations, consumer groups, research institutions, and various other organisations and stakeholders. This report was drafted based on the information obtained in these meetings, the team's preliminary assessment of Greece's energy policy, the Greek Government's response to the IEA energy policy questionnaire, and information from many other sources. The members of the review team were:

IEA member countries

Team leader: Mr Neelesh Nerurkar (United States)

Ms Gözde Ertemir (Turkey)

Mr Gábor Farkas (Hungary)

Mr Simon Koesler (Germany)

Mr Sergio Lopez (Spain)

Mr Steven May (United Kingdom)

Mr Augustijn van Haasteren (European Commission)

International Energy Agency

Mr Aad van Bohemen

Ms Sylvia Elisabeth Beyer

Mr. Joe Ritchie

Ms Dagmar Graczyk (senior country analyst)

The review team is grateful for the co-operation and assistance of the many people it met during the review visit, their kind hospitality, and their willingness to discuss the challenges and opportunities that Greece is facing.

The team is also grateful for the co-operation and assistance of the state, public, and private institutions it met throughout the visit. The visit was highly productive and enjoyable thanks to the openness and willingness of these institutions.

The team wishes to express its gratitude to Mr Michalis Verriopoulos, Secretary-General for Energy of the Ministry of Environment of Energy, for his personal engagement in the meetings and for hosting the visit. The team is also grateful to Ms Aliki Skliri, General Director for Energy in the ministry, and her team for their tireless efforts and professionalism in planning and organising the review visit. Special thanks to Mr Stelios Alifantis, Head of the Energy Strategies Analysis & Planning Department, for his patience and diligence in supporting the team throughout the review process.

The team also wishes to thank Ms Angeliki Mourtzikou, Head of the Oil and Gas Division, and Dr Dionysios Papachristou, Press and Public Relations Manager, of the Energy Regulatory Authority, for organising the site visit and for answering many requests in a patient manner.

The review was prepared under the guidance of Mr Aad van Bohemen, Head of the Energy Policy and Security Division, IEA. Ms Dagmar Graczyk managed the review and is the author of this report, with the exception of the chapters on renewable energy and energy and climate, which were written by Ms Sylvia Beyer, and the chapter on energy efficiency, which was written by Mr Joe Ritchie.

Mr Oskar Kvarnstrom prepared and drafted the sections relating to energy data contained in each chapter. Mr Aad van Bohemen, Mr Sean Calvert, Mr Carlos Fernandez-Alvarezs, Mr Thomas Nikolakakis, and Ms Carrie Pottinger contributed helpful comments throughout. Ms Dionysia Lyngopoulou and Mr Emmanouil Christinakis provided support with translation whenever needed.

The managing author is grateful for the fruitful discussions, the comments, and the substantive input provided by the review team members cited above and many other IEA colleagues.

A special thanks to the IEA Secretariat with regard to the provision of data, publication, and editing. Mr Oskar Kvarnstrom, Ms Hwayun Lee, and Mr Bertrand Sadin ensured preparation of the design of the report with figures, tables, and maps. Ms Roberta Quadrelli provided support on statistics.

Ms Muriel Custodio, Ms Astrid Dumont and Ms Katie Russel managed the publication process, Ms Therese Walsh and Ms Rebecca Gaghen provided editorial support, and Mr Jad Mouwad managed the press launch.

Organisations visited

Centre for Renewable Energy Sources and Saving (CRES)

Copelouzos Group (Renewable Energy)

DEDA (Gas Distribution Company Rest of Greece)

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)

EDA Attikis (Gas Distribution Company)

EDA Thess (Gas Distribution Company)

ENEL Green Power Hellas

ENI, S. A.

EPA Attikis (Gas Supply Company)

Gastrade, S. A.

General Secretariat of Public Revenue

General Secretariat for Research and Technology

Hellenic Association of Electricity Trading and Supply Companies (ESEPIE)

Hellenic Association of Independent Power Producers (HAIPP)

Hellenic Association of Photovoltaic Companies (HELAPCO)

Hellenic Association of Renewable Energy Sources Electricity Producers - HELLASRES

Hellenic Competition Commission (HCC)

Hellenic Electricity Distribution Network Operator (HEDNO)

Hellenic Gas Transmission System Operator (DESFA)

Hellenic Petroleum (HELPE)

Hellenic Petroleum Marketing Companies Association (SEEPE)

Hellenic Property Federation (POMIDA)

Hellenic Wind Energy Association (HWEA)

Independent Power Transmission System Operator (ADMIE)

Institute for Energy of South East Europe (IENE)

Institute of Zero Energy Buildings (INZEB)

KEPA / Energy Policy and Development Center

LAGIE (operator of electricity market)

Ministry of Economy and Development

Ministry of Environment and Energy

Ministry of Finance

Ministry of Infrastructure and Transport

MOTOR OIL

National and Kapodistrian University of Athens

National Observatory of Athens (NOA)

National Technical University of Athens

PPC Renewables

Public Gas Corporation (DEPA)

Public Power Corporation (PPC)

Regulatory Authority for Energy (RAE)

Shell

ANNEX B: Energy balances and key statistical data

Greece

Energy balances and key statistical data

Unit: Mtoe

SUPPLY		1973	1990	2000	2010	2013	2014	2015	2016E
TOTAL PRODUCTION		**2.33**	**9.20**	**9.99**	**9.43**	**9.31**	**8.80**	**8.47**	**6.83**
Coal		1.69	7.12	8.22	7.32	6.73	6.38	5.68	3.96
Peat		-	-	-	-	-	-	-	-
Oil		-	0.84	0.26	0.11	0.06	0.06	0.06	0.15
Natural gas		-	0.14	0.04	0.01	0.01	0.01	0.01	0.01
Biofuels and waste[1]		0.45	0.89	1.01	0.92	1.09	1.12	1.27	1.25
Nuclear		-	-	-	-	-	-	-	-
Hydro		0.19	0.15	0.32	0.64	0.55	0.39	0.52	0.48
Wind		-	-	0.04	0.23	0.36	0.32	0.40	0.44
Geothermal		-	0.00	0.00	0.02	0.01	0.01	0.01	0.01
Solar/other[2]		-	0.06	0.10	0.20	0.50	0.52	0.53	0.54
TOTAL NET IMPORTS[3]		**10.58**	**12.00**	**17.39**	**17.91**	**13.38**	**14.28**	**15.77**	**15.99**
Coal	Exports	0.02	-	0.04	-	0.01	0.01	-	0.01
	Imports	0.47	0.92	0.81	0.40	0.23	0.20	0.16	0.20
	Net imports	0.45	0.92	0.77	0.40	0.23	0.19	0.16	0.19
Oil	Exports	4.88	7.45	4.08	9.59	14.26	15.65	16.34	18.36
	Imports	16.47	21.79	23.40	26.61	26.68	29.04	30.93	32.32
	Int'l marine and aviation bunkers	-1.46	-3.32	-4.38	-3.39	-2.80	-2.64	-2.61	-2.53
	Net imports	10.12	11.02	14.94	13.63	9.63	10.75	11.99	11.44
Natural Gas	Exports	-	-	-	-	-	-	-	-
	Imports	-	-	1.69	3.23	3.23	2.47	2.67	3.46
	Net imports	-	-	1.69	3.23	3.23	2.47	2.67	3.46
Electricity	Exports	0.00	0.05	0.15	0.24	0.34	0.06	0.13	0.09
	Imports	0.01	0.11	0.15	0.73	0.50	0.81	0.95	0.85
	Net imports	0.00	0.06	-0.00	0.49	0.16	0.76	0.83	0.76
TOTAL STOCK CHANGES		**-1.10**	**0.24**	**-0.29**	**0.26**	**0.65**	**0.05**	**-1.05**	**0.09**
TOTAL SUPPLY (TPES)[4]		**11.81**	**21.44**	**27.09**	**27.60**	**23.33**	**23.13**	**23.19**	**22.91**
Coal		2.10	8.07	9.04	7.86	6.98	6.69	5.61	4.36
Peat		-	-	-	-	-	-	-	-
Oil		9.06	12.07	14.88	13.85	10.32	10.74	11.21	11.45
Natural gas		-	0.14	1.70	3.23	3.24	2.48	2.68	3.49
Biofuels and waste[1]		0.45	0.89	1.01	1.08	1.22	1.23	1.40	1.39
Nuclear		-	-	-	-	-	-	-	-
Hydro		0.19	0.15	0.32	0.64	0.55	0.39	0.52	0.48
Wind		-	-	0.04	0.23	0.36	0.32	0.40	0.44
Geothermal		-	0.00	0.00	0.02	0.01	0.01	0.01	0.01
Solar/other[2]		-	0.06	0.10	0.20	0.50	0.52	0.53	0.54
Electricity trade[5]		0.00	0.06	-0.00	0.49	0.16	0.76	0.83	0.76
Shares in TPES (%)									
Coal		*17.8*	*37.6*	*33.4*	*28.5*	*29.9*	*28.9*	*24.2*	*19.0*
Peat		-	-	-	-	-	-	-	-
Oil		*76.7*	*56.3*	*54.9*	*50.2*	*44.2*	*46.4*	*48.4*	*50.0*
Natural gas		-	*0.6*	*6.3*	*11.7*	*13.9*	*10.7*	*11.5*	*15.2*
Biofuels and waste[1]		*3.8*	*4.2*	*3.7*	*3.9*	*5.2*	*5.3*	*6.1*	*6.1*
Nuclear		-	-	-	-	-	-	-	-
Hydro		*1.6*	*0.7*	*1.2*	*2.3*	*2.3*	*1.7*	*2.3*	*2.1*
Wind		-	-	*0.1*	*0.8*	*1.5*	*1.4*	*1.7*	*1.9*
Geothermal		-	*0.0*	*0.0*	*0.1*	*0.1*	*0.1*	*0.0*	*0.0*
Solar/other[2]		-	*0.3*	*0.4*	*0.7*	*2.1*	*2.2*	*2.3*	*2.3*
Electricity trade[5]		-	*0.3*	-	*1.8*	*0.7*	*3.3*	*3.6*	*3.3*

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.

Unit: Mtoe

DEMAND							
FINAL CONSUMPTION	**1973**	**1990**	**2000**	**2010**	**2013**	**2014**	**2015**
TFC	**8.53**	**14.49**	**18.46**	**19.43**	**15.26**	**15.45**	**16.38**
Coal	0.52	1.22	0.88	0.30	0.21	0.23	0.22
Peat	-	-	-	-	-	-	-
Oil	6.47	9.78	12.41	12.18	8.26	8.39	8.92
Natural gas	-	0.10	0.38	1.14	1.23	1.18	1.32
Biofuels and waste[1]	0.45	0.89	0.95	1.00	1.13	1.14	1.30
Geothermal	-	0.00	0.00	0.02	0.01	0.01	0.01
Solar/other[2]	-	0.06	0.10	0.18	0.19	0.19	0.20
Electricity	1.09	2.45	3.71	4.57	4.20	4.26	4.37
Heat	-	-	0.03	0.05	0.04	0.05	0.05
Shares in TFC (%)							
Coal	*6.1*	*8.4*	*4.8*	*1.6*	*1.4*	*1.5*	*1.4*
Peat	-	-	-	-	-	-	-
Oil	*75.8*	*67.5*	*67.3*	*62.7*	*54.1*	*54.3*	*54.4*
Natural gas	-	*0.7*	*2.0*	*5.8*	*8.1*	*7.6*	*8.0*
Biofuels and waste[1]	*5.3*	*6.2*	*5.1*	*5.1*	*7.4*	*7.4*	*7.9*
Geothermal	-	-	-	*0.0*	*0.0*	*0.0*	*0.1*
Solar/other[2]	-	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*1.2*
Electricity	*12.8*	*16.9*	*20.1*	*23.5*	*27.5*	*27.5*	*26.7*
Heat	-	-	*0.2*	*0.2*	*0.3*	*0.3*	*0.3*
TOTAL INDUSTRY[6]	**3.47**	**4.68**	**5.16**	**4.58**	**3.49**	**3.79**	**3.83**
Coal	0.46	1.18	0.85	0.30	0.21	0.23	0.22
Peat	-	-	-	-	-	-	-
Oil	2.38	2.17	2.54	2.09	1.31	1.49	1.48
Natural gas	-	0.10	0.37	0.73	0.86	0.81	0.78
Biofuels and waste[1]	-	0.19	0.23	0.25	0.13	0.16	0.26
Geothermal	-	-	-	-	-	-	-
Solar/other[2]	-	-	-	-	0.00	0.00	0.00
Electricity	0.63	1.04	1.17	1.22	0.98	1.11	1.09
Heat	-	-	-	-	-	-	-
Shares in total industry (%)							
Coal	*13.2*	*25.3*	*16.5*	*6.5*	*6.1*	*6.0*	*5.7*
Peat	-	-	-	-	-	-	-
Oil	*68.5*	*46.3*	*49.3*	*45.7*	*37.6*	*39.1*	*38.7*
Natural gas	-	*2.1*	*7.1*	*15.9*	*24.6*	*21.4*	*20.4*
Biofuels and waste[1]	-	*4.1*	*4.5*	*5.3*	*3.7*	*4.3*	*6.8*
Geothermal	-	-	-	-	-	-	-
Solar/other[2]	-	-	-	-	-	-	-
Electricity	*18.3*	*22.2*	*22.6*	*26.6*	*28.1*	*29.2*	*28.4*
Heat	-	-	-	-	-	-	-
TRANSPORT[4]	**2.07**	**5.04**	**6.40**	**7.48**	**5.61**	**5.64**	**5.76**
OTHER[7]	**2.99**	**4.77**	**6.90**	**7.37**	**6.17**	**6.02**	**6.80**
Coal	0.05	0.03	0.03	0.00	0.00	0.01	0.01
Peat	-	-	-	-	-	-	-
Oil	2.04	2.58	3.50	2.77	1.50	1.45	1.88
Natural gas	-	-	0.01	0.39	0.36	0.36	0.52
Biofuels and waste[1]	0.45	0.70	0.71	0.62	0.88	0.84	0.89
Geothermal	-	0.00	0.00	0.02	0.01	0.01	0.01
Solar/other[2]	-	0.06	0.10	0.18	0.19	0.19	0.20
Electricity	0.46	1.40	2.53	3.34	3.20	3.12	3.25
Heat	-	-	0.03	0.05	0.04	0.05	0.05
Shares in other (%)							
Coal	*1.5*	*0.7*	*0.4*	-	-	*0.1*	*0.1*
Peat	-	-	-	-	-	-	-
Oil	*68.3*	*54.1*	*50.7*	*37.6*	*24.3*	*24.0*	*27.6*
Natural gas	-	-	*0.2*	*5.3*	*5.8*	*5.9*	*7.7*
Biofuels and waste[1]	*15.0*	*14.7*	*10.3*	*8.4*	*14.2*	*13.9*	*13.1*
Geothermal	-	*0.1*	-	*0.0*	*0.0*	*0.0*	*0.1*
Solar/other[2]	-	*1.2*	*1.4*	*2.5*	*3.0*	*3.2*	*2.9*
Electricity	*15.2*	*29.3*	*36.6*	*45.3*	*51.8*	*51.8*	*47.7*
Heat	-	-	*0.4*	*0.6*	*0.7*	*0.8*	*0.7*

Greece

Unit: Mtoe

DEMAND								
ENERGY TRANSFORMATION AND LOSSES	**1973**	**1990**	**2000**	**2010**	**2013**	**2014**	**2015**	**2016E**
ELECTRICITY GENERATION[8]								
Input (Mtoe)	3.33	8.89	11.98	12.17	11.28	10.04	9.55	..
Output (Mtoe)	1.27	2.99	4.59	4.93	4.91	4.33	4.46	4.20
Output (TWh)	14.82	34.78	53.43	57.37	57.11	50.34	51.82	48.81
Output Shares (%)								
Coal	*35.5*	*72.4*	*64.2*	*53.7*	*46.2*	*51.1*	*42.7*	*31.6*
Peat	-	-	-	-	-	-	-	-
Oil	*49.5*	*22.3*	*16.6*	*10.6*	*9.5*	*11.0*	*10.9*	*9.9*
Natural gas	-	*0.3*	*11.1*	*17.1*	*19.0*	*13.5*	*17.5*	*27.8*
Biofuels and waste[1]	-	-	*0.3*	*0.6*	*0.5*	*0.6*	*0.7*	*0.7*
Nuclear	-	-	-	-	-	-	-	-
Hydro	*15.0*	*5.1*	*6.9*	*13.0*	*11.1*	*8.9*	*11.8*	*11.4*
Wind	-	-	*0.8*	*4.7*	*7.2*	*7.3*	*8.9*	*10.5*
Geothermal	-	-	-	-	-	-	-	-
Solar/other[2]	-	-	-	*0.3*	*6.4*	*7.5*	*7.5*	*8.1*
TOTAL LOSSES	**3.28**	**7.23**	**8.90**	**8.59**	**8.25**	**7.28**	**6.67**	**..**
of which:								
Electricity and heat generation[9]	2.06	5.90	7.36	7.19	6.33	5.66	5.05	..
Other transformation	0.59	0.00	-0.39	-0.58	-0.36	-0.58	-0.59	..
Own use and transmission/distribution losses[10]	0.64	1.32	1.94	1.98	2.28	2.21	2.22	..
Statistical Differences	**0.00**	**-0.28**	**-0.27**	**-0.41**	**-0.18**	**0.40**	**0.14**	**..**
INDICATORS	**1973**	**1990**	**2000**	**2010**	**2013**	**2014**	**2015**	**2016E**
GDP (billion 2010 USD)	151.21	197.65	251.51	299.36	243.99	244.85	244.31	244.34
Population (millions)	9.02	10.27	10.81	11.12	10.97	10.89	10.86	10.88
TPES/GDP (toe/1000 USD)[11]	0.08	0.11	0.11	0.09	0.10	0.09	0.09	0.09
Energy production/TPES	0.20	0.43	0.37	0.34	0.40	0.38	0.37	0.30
Per capita TPES (toe/capita)	1.31	2.09	2.51	2.48	2.13	2.12	2.14	2.11
Oil supply/GDP (toe/1000 USD)[11]	0.06	0.06	0.06	0.05	0.04	0.04	0.05	0.05
TFC/GDP (toe/1000 USD)[11]	0.06	0.07	0.07	0.06	0.06	0.06	0.07	..
Per capita TFC (toe/capita)	0.95	1.41	1.71	1.75	1.39	1.42	1.51	..
CO_2 emissions from fuel combustion ($MtCO_2$)[12]	33.7	69.9	88.0	83.4	68.9	65.8	64.6	..
CO_2 emissions from bunkers ($MtCO_2$)[12]	4.6	10.5	13.9	10.8	8.9	8.3	8.2	..
GROWTH RATES (% per year)	**73-90**	**90-00**	**00-10**	**10-12**	**12-13**	**13-14**	**14-15**	**15-16**
TPES	3.6	2.4	0.2	-1.9	-12.1	-0.9	0.2	-1.2
Coal	8.2	1.1	-1.4	1.7	-14.2	-4.2	-16.2	-22.3
Peat	-	-	-	-	-	-	-	-
Oil	1.7	2.1	-0.7	-6.4	-15.0	4.1	4.4	2.1
Natural gas	-	28.6	6.6	6.4	-11.6	-23.2	7.7	30.4
Biofuels and waste[1]	4.1	1.2	0.6	14.6	-13.3	1.0	13.6	-1.1
Nuclear	-	-	-	-	-	-	-	-
Hydro	-1.3	7.7	7.3	-23.2	44.1	-29.5	36.1	-9.0
Wind	-	-	19.6	19.2	7.6	-11.0	25.2	11.6
Geothermal	-	-4.0	23.1	-9.9	-7.7	0.0	-16.7	0.0
Solar/other[2]	-	5.9	7.1	29.4	51.8	3.4	2.7	0.8
TFC	3.2	2.4	0.5	-6.3	-10.6	1.2	6.0	..
Electricity consumption	4.9	4.2	2.1	-1.0	-6.2	1.5	2.6	..
Energy production	8.4	0.8	-0.6	5.1	-10.7	-5.5	-3.8	-19.3
Net oil imports	0.5	3.1	-0.9	-4.8	-22.0	11.7	11.5	-4.6
GDP	1.6	2.4	1.8	-8.2	-3.2	0.4	-0.2	0.0
TPES/GDP	2.0	-0.1	-1.5	6.9	-9.2	-1.2	0.5	-1.2
TFC/GDP	1.6	0.0	-1.2	2.1	-7.5	0.8	6.3	..

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.

Footnotes to energy balances and key statistical data

1. Biofuels and waste comprises solid biofuels, liquid biofuels, biogases, and industrial waste. Data are often based on partial surveys and may not be comparable among countries.
2. Solar/other includes solar photovoltaics and solar thermal.
3. In addition to coal, oil, natural gas, and electricity, total net imports also includes biofuels and waste.
4. Excludes international marine bunkers and international aviation bunkers.
5. Total supply of electricity represents net trade. A negative number in the share of TPES indicates that exports are greater than imports.
6. Industry includes non-energy use.
7. Other includes residential, commercial and public services, agriculture/forestry, fishing, and other non-specified.
8. Inputs to electricity generation includes inputs to electricity, co-generation, and heat plants. Output refers only to electricity generation.
9. 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 33% for solar thermal and 100% for hydro, wind, and solar photovoltaics.
10. Data on "losses" for forecast years often include large statistical differences covering differences between expected supply and demand and mostly do not reflect real expectations on transformation gains and losses.
11. Toe per thousand USD at 2010 prices and exchange rates.
12. "CO_2 emissions from fuel combustion" have been estimated using the Intergovernmental Panel on Climate Change (IPCC) tier I sectoral approach from the *2006 IPCC Guidelines.* In accordance with the IPCC methodology, emissions from international marine and aviation bunkers are not included in national totals.

ANNEX C: International Energy Agency "Shared Goals"

The member countries* of the International Energy Agency (IEA) seek to create conditions in which the energy sectors of their economies can make the fullest possible contribution to sustainable economic development and to the well-being of their people and of the environment. In formulating energy policies, the establishment of free and open markets is a fundamental point of departure, though energy security and environmental protection need to be given particular emphasis by governments. IEA countries recognise the significance of increasing global interdependence in energy. They therefore seek to promote the effective operation of international energy markets and encourage dialogue with all participants. In order to secure their objectives, member countries therefore aim to create a policy framework consistent with the following goals:

1. Diversity, efficiency and flexibility within the energy sector are basic conditions for longer-term energy security: the fuels used within and across sectors and the sources of those fuels should be as diverse as practicable. Non-fossil fuels, particularly nuclear and hydro power, make a substantial contribution to the energy supply diversity of IEA countries as a group.

2. Energy systems should have **the ability to respond promptly and flexibly to energy emergencies.** In some cases this requires collective mechanisms and action: IEA countries co-operate through the Agency in responding jointly to oil supply emergencies.

3. The environmentally sustainable provision and use of energy are central to the achievement of these shared goals. Decision-makers should seek to minimise the adverse environmental impacts of energy activities, just as environmental decisions should take account of the energy consequences. Government interventions should respect the Polluter Pays Principle where practicable.

4. More environmentally acceptable energy sources need to be encouraged and developed. Clean and efficient use of fossil fuels is essential. The development of economic non-fossil sources is also a priority. A number of IEA member countries wish to retain and improve the nuclear option for the future, at the highest available safety standards, because nuclear energy does not emit carbon dioxide. Renewable sources will also have an increasingly important contribution to make.

5. Improved energy efficiency can promote both environmental protection and energy security in a cost-effective manner. There are significant opportunities for greater energy efficiency at all stages of the energy cycle from production to consumption. Strong efforts by governments and all energy users are needed to realise these opportunities.

6. Continued **research, development and market deployment of new and improved energy technologies** make a critical contribution to achieving the objectives outlined above. Energy technology policies should complement broader energy policies. International co-operation in the development and dissemination of energy technologies, including industry participation and co-operation with non-member countries, should be encouraged.

7. Undistorted energy prices enable markets to work efficiently. Energy prices should not be held artificially below the costs of supply to promote social or industrial goals. To the extent necessary and practicable, the environmental costs of energy production and use should be reflected in prices.

8. Free and open trade and a secure framework for investment contribute to efficient energy markets and energy security. Distortions to energy trade and investment should be avoided.

9. Co-operation among all energy market participants helps to improve information and understanding, and encourages the development of efficient, environmentally acceptable and flexible energy systems and markets worldwide. These are needed to help promote the investment, trade and confidence necessary to achieve global energy security and environmental objectives.

(The Shared Goals were adopted by IEA Ministers at the meeting of 4 June 1993 Paris, France.)

* Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Luxembourg, the Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Spain, Sweden, Switzerland, Turkey, the United Kingdom, the United States.

ANNEX D: 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

ADMIE	Independent Power Transmission Operator
CRES	Centre for Renewable Energy Sources and Saving
DAS	day-ahead scheduling
DEDA	Gas Distribution Company Rest of Greece
DEPA	Public Gas Corporation S.A.
DESFA	Hellenic Gas Transmission System Operator
DSO	distribution system operator
EAP	economic adjustment programme
EC	European Commission
EIA	environmental impact assessment
ETMEAR	existing renewable energy source levy
ETS	Emissions Trading System
EU	European Union
FiT	feed-in tariff
FiP	feed-in premium
FSRU	floating storage and regasification unit
FYROM	Former Yugoslav Republic of Macedonia
GDP	gross domestic product
GDP PPP	gross domestic product with purchasing power parity
GHG	greenhouse gas
GSRI	Greek Strategy for Research and Innovation
HCC	Hellenic Competition Commission
HEDNO	Hellenic Electricity Distribution Network Operator
HELPE	Hellenic Petroleum
HETSO	Hellenic Electricity Transmission and Market Operator
HHRM	Hellenic Hydrocarbon Resources Management S.A.
HRADF	Hellenic Republic Asset Development Fund
IED	Integrated Emission Directive
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent Power Producers
ITO	independent transmission operator
LAGIE	Hellenic Electricity Market Operator
LNG	liquefied natural gas

LULUCF	land use, land-use change and forestry
NII	non-interconnected island
NNGS	national natural gas system
NNGTS	national natural gas transmission system
NOME	Nouvelle Organisation due Marché de l'Electricité
NREAP	national renewable energy action plan
PCI	project of common interest
PPC	Public Power Corporation
PPP	purchasing power parity
PSO	public service obligation
PV	photovoltaic
RAE	Regulatory Authority for Energy
R&D	research and development
RD&D	research, development, and demonstration
SOCAR	State Oil Company of Azerbaijan
TCP	technology collaboration programme
TFC	total final consumption
TPES	total primary energy supply
TSO	transmission system operator

Units of measurement

bcm	billion cubic metres
CO_2	carbon dioxide
gCO_2	gramme of carbon dioxide
GJ	gigajoule
GW	gigawatt
kg	
$kgCO_2$	kilogramme of carbon dioxide
kL	kilolitre
km	kilometre
ktoe	thousand tonnes of oil equivalent
kV	kilovolt
kW	kilowatt
kWh	kilowatt hour
m^3	cubic metre
mcm	million cubic metres
Mt	million tonnes
$MtCO_2$	million tonnes of carbon dioxide
$MtCO_2$-eq	million tonnes of carbon dioxide equivalent
Mtoe	million tonnes of oil equivalent

MW	megawatt
MWh	megawatt hour
tCO_2	tonne of carbon dioxide
toe	tonne of oil equivalent
TWh	terawatt hour


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IEA Publications,
International Energy Agency
Website: www.iea.org
Contact information: www.iea.org/aboutus/contactus
Typeset in France and Printed in France by IEA, October 2017
Cover design: IEA. Photo credits: © GraphicObsession.

IEA/OECD possible corrigenda on: www.oecd.org/about/publishing/corrigenda.htm

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ENERGY POLICIES OF IEA COUNTRIES

Greece

2017 Review

Greece is currently implementing comprehensive energy sector reforms towards creating competitive energy markets. The reforms will reveal opportunities for investors and for transformation of the energy system, thereby providing sustainable outcomes for the environment and for Greek society. This International Energy Agency review highlights the areas that are critical to the success of Greece's energy policy agenda.

Greece can use the economic recovery as an opportunity to get ahead with longer-term emissions reduction outcomes by pursuing initiatives that support sustainable increases in efficiency and by increasing the share of natural gas and renewable energy in the energy mix. A key part of this process will be to develop a national energy and climate plan for 2030 and beyond, as well as to incorporate climate objectives into integrated energy planning.

The country has seen an impressive increase in the share of renewables in electricity generation, even over-achieving the targets set for solar photovoltaics. Enhanced exploitation of its renewable energy potential could result in a more balanced energy mix and contribute to increasing energy security.

Greece should continue pursuing the implementation of ambitious energy efficiency policies, drawing on the evaluation of outcomes from past and current measures and on the lessons learned by other countries. This review also provides recommendations for further policy improvements that are intended to help guide the country towards a more secure and sustainable energy future.