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Dissertation

GREEK ENERGY MARKET AND INVESTMENTS

THE ENVIRONMENT OF 20's

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Affirmation

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Abstract

Since November 2020, Greece participates in the Target Model - the single wholesale market model applied in all EU countries. Greece is thus complying with a fundamental obligation towards the EU for the creation of a single European electricity market to remove trade restrictions and allow the connection between national markets. The promotion of competition, the greater convergence of prices in the Greek market with neighbouring ones, the formation of a transparent framework for market costs, the highest quality operation of the electricity system, and the efficient use of energy resources will ultimately benefit the Greek economy and the Greek consumers through extended access to cheaper energy sources and PPAs.

By 2023, Greece is expected to have completed major advancements in energy transition despite its macroeconomic challenges such as lower public revenues, higher government expenditures, debt accumulation, and the threat of increased non-performing loans due to the COVID-19 pandemic. At the same time, tackling climate change and the need to improve air quality in the Greek ports requires an urgent energy transformation. Ports must become energy hubs, where the production, storage and distribution of electricity will coexist. Europe is already shifting to greener ports, having placed tackling climate change a top priority over the coming years. Greece has a strong maritime tradition and many ports. This is a competitive advantage and provides a motive to act in a coordinated way to reduce their environmental footprint. As a popular tourist destination, Greece accepts different types of ships, including cruise ships with high energy needs. In this direction, zeroing ship pollutants by providing energy from the land to avoid the use of their engines that burn oil is an especially important step.

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1. Introduction

Energy as a primary good has become a major issue both on a European and global level. The increasing demand for the provision of higher quantity and better quality of energy has motivated new players to enter the market and has contributed to the restriction of monopolies in the industry (Ergunova, 2018). These developments have led to new long-term negotiations regarding the creation of a new framework for liberating the energy market and the energy economy (De Hauteclocque and Glachant, 2009).

The creation of a single and competitive energy market has become one of the basic pillars of the European Union and a top priority of the European countries. Advocates of the liberalization of the energy market suggest that it facilitates the integration of the internal energy market. Consequently, it leads to more efficient production, better transport and distribution of energy, and higher safety of the supply chain while strengthening the competitiveness of the European economy and protecting the environment (Marchi and Zanoni, 2017).

The adoption of a new regulatory framework has set the foundations for the redistribution of rights and responsibilities towards the protection of the EU's financial interests. Directive 96/92/EC of the European Parliament concerning "common rules for the internal market in electricity"[1] served as the framework for the procedures pertaining to the liberalization of the energy markets of the EU members and the course of actions towards the integration of the internal energy market (Talus and Aalto, 2017).

In Greece, the harmonization with Directive 96/92/EC was realized with Law 2773/1999[2] and the newer Directive 2003/54/EC "concerning common rules for the internal market in electricity and repealing Directive 96/92/EC."[3] The third package of measures was introduced with Directive 2009/72/EC "concerning common rules for the internal market in electricity and repealing Directive

[1] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31996L0092&from=EN
[2] http://www.res-legal.eu/search-by-country/greece/sources/t/source/src/law-no-27731999/
[3] https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32003L0054&from=EN

2003/54/EC"[4], and was integrated into the national legislation with Law 4001/2011.[5]

The objectives of the Directive 2009/72/EC are the ability to select a provider of electrical energy, the strengthening of global trade and transnational cooperation, and the development of competitive prices, high quality of energy supply, and the satisfaction of energy demand.

Energy, logistics, and tourism sectors are strategic for the Greek economy and have great growth potential. Especially, the energy sector is a crucial pillar for the transition towards sustainable growth and extroversion. As of 2018, its direct contribution is 2.7% of the Gross Value Added (GVA) and 0.7% of employment, excluding wholesale and retail trade activities (Karavias and Anastasatos, 2018). Further, given the country's geopolitical position and the comparative advantages derived, the disposal of renewable and fossil resources, and the continuing liberalization of electricity and gas wholesale and retail markets, Greece is expected to generate a higher direct contribution of the energy sector to GDP (HAEE, 2019).

Greece's energy investments in small and major production and management projects are expected to be important drivers of development not only for the energy sector but also for the Greek economy. At an institutional level, the energy market waits for the spatial planning for Renewable Energy Systems (RES). This is expected to contribute to the attraction of investments on specific term conditions, thereby achieving national energy targets transition and strengthening the participation of RES in the energy mix (Papageorgiou, 2017).

Today, significant investment opportunities take place in the primary energy sector (e.g., research and production of hydrocarbons, RES, and energy efficiency), but also in transport, distribution, and gas and electricity infrastructure. The estimated energy investments in Greece for the period 2018-2027, amount to €45.5 billion if Greece follows a path of growth rather than recession over the next decade with an average annual growth rate of around 1.5% (IENE, 2019). Further, pipelines are being installed across the Greek

[4] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009L0072&from=EN

[5] https://www.depa.gr/wp-content/uploads/2018/12/n_4001_2011.pdf (in Greek)

territory and the research for hydrocarbon reserves continues. These developments along with an anticipated 35% of energy coming from RES by 2030, are playing a significant role in the effort to transform Greece into a regional energy hub (Greece Investor Guide, 2020).

On the other hand, the economic uncertainty, the weak regulatory framework, and the compromising infrastructure security are challenges that need to be addressed as they affect both short-term and long-term energy investments. As internationally supported, the Greek energy sector to be transformed and address the critical factor for competitive energy costs (Manolkidis, 2021).

1.1 Aim of the dissertation

The aim of the dissertation is to analyse the financial and strategic view of the energy sector in Greece and to interpret the economic impact of the private and state energy investments that take place in the Greek territory in a challenge period such us the decade after 2020. To that end, it investigates the contribution of the energy sector to GDP and unemployment, and it assesses the macroeconomic and microeconomic effects on the growth and extroversion of the Greek economy.

1.2 Methodology

The dissertation employs secondary data collection and quantitative analysis. The data is collected from reliable sources, including the IEA, Eurostat, EIA. Statista as well as from state platforms such as DAPEEP, Hellenic Competition Commission, Regulatory Authority for Energy etc.

The purpose of the methodology is to investigate the public and private investments in energy sectors such as rrenewable energy sources, oil industry & companies at the field of petroleum, Gas & LNG, coal industry, power plants, LNG processing plants, energy constructions, electromobility, energy buildings, pipelines, etc. Further, it will collect information from major Greek companies that engage in energy investments from all the market fields.

1.3 Structure of the study

Following the introductory part, Chapter 2 presents the energy market in Greece, the energy balance, and the impact of the COVID-19 pandemic on the Greek energy market. It also presents oil and petroleum products, the legislative framework for energy transition and the Target model. Further, it analyses natural gas, renewqable energy sources (RES), energy efficiency and co-production and energy poverty in Greece. The chapter is completed with the presentation and analysis of the National Energy and Climate Plan (NECP) and a thorough reporting of the climate energy targets, the RES targets, the energy efficiency targets, the strategies implemented to address the Energy Union dimensions and the challenges posed ahead.

Chapter 3 performs a sector analysis regarding the oil industry companies, natural gas and LNG, coal industry, power plants, LNG processing plants, energy constructions, electromobility, and energy buildings.

Chapter 4 investigates e-mobility and electric cars in Greece.

Chapter 5 presents energy investments from Greek companies.

Chapter 6 analyses the impact of energy investments both on a global and national level and explains the use of RES technologies and the importance of Power Purchase Agreements (PPAs). Also, it presents the next day for energy in Greece.

The Dissertation is completed with conclusion and suggestions in Chapter 7.

1.4 Contribution of the study

Energy as a general term is especially important for everyday life, yet the steps of growth in Greece are small. We expect that the introduction of the Target Model and the spatial planning for Renewable Energy Systems will change the scenery. To the end, the dissertation will extensively study the development of recent years but will focus on the future of energy investments and the economy in Greece. The aim is to better understand the contribution of the energy market to the economy and to assess the opportunities for further investments.

2. The energy market in Greece

2.1 Introduction

In 2020, Greece achieved a record year in 2020 for gas consumption with an increase of 9.6% compared to 2019 and 99% compared to 2014. Electricity producers covered 65% of gas demand, distribution network and Compressed natural gas (CNG) covered 18.5%, and the energy industry covered 16.5% of demand. Also, there was a significant increase in gas imports from the USA, from 2.5 TWh in 2019 to 16 TWh in 2020 (+540.0%) (RAE, 2021). All these developments call for the investigation of how the energy market operates in Greece and what is the country's potential in Energy Transition and related investments.

Since the early 1990s, the European Energy Union has been one of the priorities of the European Commission, given that the provision of reliable, reasonably priced, and environmentally friendly energy to enterprises and households is a key factor for the European economy. In this context, the European Union attempted in the mid-1990s the liberalization of the electricity market, which was driven by state monopolistic enterprises.

The electricity market liberalization aimed to open the market to competition for achieving:

- The clear distinction between competitive (e.g., the supply of electricity to consumers) and non-competitive (network operation) activities.
- The obligation of the operators of non-competitive activities to allow third parties access to their infrastructure (e.g., network connection).
- The removal of electricity obstacles to the activity of alternative suppliers.
- The phasing out of supplier selection restrictions by consumers.
- The creation of independent market surveillance regulators.

The network transmission system in Greece includes the high-voltage network and electricity distribution network. The management of the medium and lowvoltage network is entrusted to the Hellenic Electricity Distribution Network Operator (HEDNO), a 100% subsidiary of Public Power Corporation (PPC). HEDNO is responsible for operating, maintaining, and developing the electricity distribution network in Greece and ensuring transparent and non-discriminatory access for all consumers (both enterprises and households) (HEDNO, 2021). Accordingly, the management of the transmission system is entrusted to the Independent Power Transmission Operator (IPTO or ADMIE), which also a 100% subsidiary of PPC. IPTO is responsible for the operation, maintenance, and development of the Hellenic Electricity Transmission System to ensure sufficient, reliable, and efficient supply of electricity in compliance with the principles of transparency, equality, and free competition (IPTO, 2021).

2.1.1 The Greek energy balance

The structure of the Greek energy market aimed at achieving the European strategic objectives for liberalizing the procurement activity of electricity and lifting supplier selection restrictions by consumers. In this context, the European intervention on the structure of the networks aimed at a clear distinction between competitive and non-competitive activities and third-party access to the infrastructure of non-EU competitive activities (Fafaliou and Polemis, 2010).

Greece produces a large amount of lignite covering a significant part of the electricity generation. Lignite is still the dominant fuel in electricity generation, currently representing almost one third of total production. Particularly important is the production of electricity from renewable energy source (RES), mainly hydropower, photovoltaics, wind, geothermal and biofuels. Also, there is small oil production and almost negligible natural gas production (IENE, 2019).

The Greek energy balance includes electricity, crude oil, and natural gas. Compared to Europe per capita, average own consumption and production of electricity per capita in Greece are slightly lower, import of electricity per capita is slightly higher, and export of electricity per capita is significantly lower. Also, the import of crude oil per capita in Greece is 0.045 barrels of oil (bbl) compared to 0.020 barrels of oil (bbl) in Europe per capita while production and export move in line. Finally, natural gas production per capita lags Europe per capita while own consumption and import are close to 50% of Europe per capita (Table 2-1).

Table 2-1 Greece's Energy Balance (2019)

Electricity	**total**	**Greece per capita**	**Compared to Europe per capita**
Own consumption	56.89 bn kWh	5,308.72 kWh	5,511.05 kWh
Production	52.05 bn kWh	4,857.08 kWh	5,925.27 kWh
Import	9.83 bn kWh	917.57 kWh	729.94 kWh
Export	1.04 bn kWh	96.77 kWh	707.85 kWh
Crude Oil	**Barrel**	**Greece per capita**	**Compared to Europe per capita**
Production	4,100.00 bbl	0.000 bbl	0.005 bbl
Import	484,300.00 bbl	0.045 bbl	0.020 bbl
Export	3,229.00 bbl	0.000 bbl	0.004 bbl
Natural Gas	**Cubic meters**	**Greece per capita**	**Compared to Europe per capita**
Own consumption	4.93 bn m³	459.77 m³	903.40 m³
Production	8.00 m m³	0.75 m³	456.61 m³
Import	4.98 bn m³	465.08 m³	854.09 m³

Source: WordData (2021)

The total production capacity of the Greek energy market is 167.93 bn kWh with fossil fuels accounting for 57.0% (95.72 bn kWh) followed by renewable energy 29.0% (48.70 bn kWh) and waterpower 14.0% (23.51 bn kWh). Compared to Europe, the percentage of fossil fuels and renewable energy production capacities in Greece is higher while the percentage of waterpower production capacities is lower. In per capita measurements, the total production capacity in Greece is lower than the total production capacity in Europe (15,670.41 kWh vs 16,489.87 kWh) (Table 2-2).

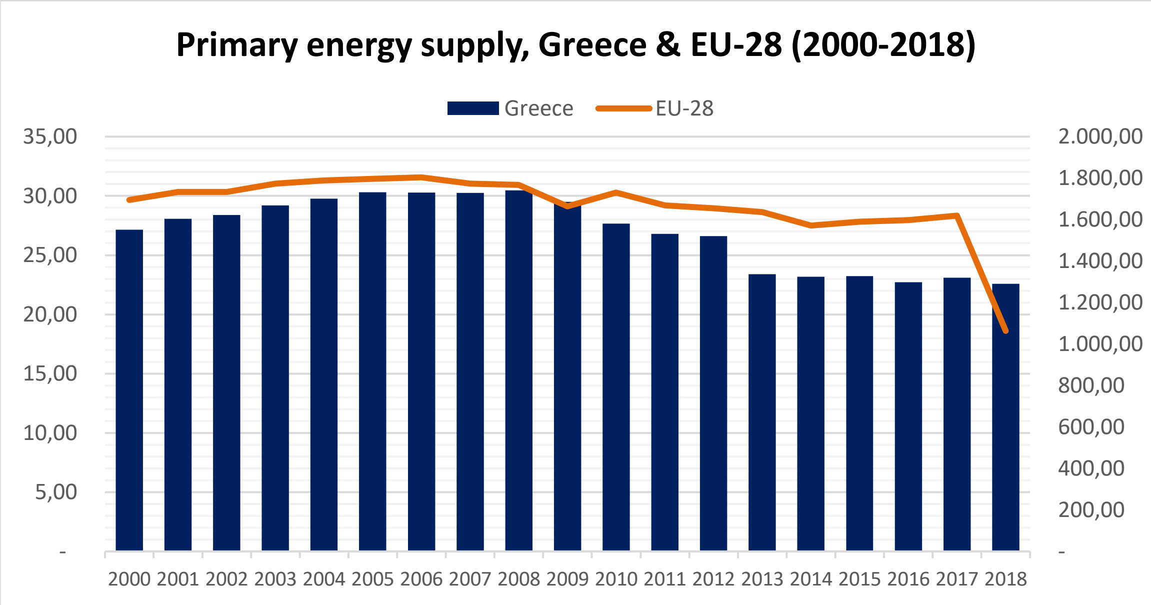
Table 2-2 Production capacities per energy source in Greece

Energy source	**total in Greece**	**percentage in Greece**	**percentage in Europe**	**per capita in Greece**	**per capita in Europe**
Fossil fuels	95.72 bn kWh	57,0%	49,2%	8,932.14 kWh	8,115.37 kWh
Nuclear power	0.00 kWh	0,0%	7,0%	0.00 kWh	1,154.29 kWh
Waterpower	23.51 bn kWh	14,0%	24,1%	2,193.86 kWh	3,977.20 kWh
Renewable energy	48.70 bn kWh	29,0%	19,7%	4,544.42 kWh	3,274.42 kWh
TTL production capacity	167.93 bn kWh	100,0%	100,0%	15,670.41 kWh	16,489.87 kWh

Source: WordData (2021)

Greece's share of primary energy supply in the EU-28 ranges between 1.60% in 2000 to 2.12% in 2018. The highest supply can be seen between 2005 and 2008, 30.33 million toes and the lowest supply can be seen from 2013 onwards, 23.04 million toes on average (Figure 2-1).

Figure 2-1 Primary energy supply, Greece & EU-28 (2000-2018)



Source: OECD (2021)

Table 2-3 summarizes total energy demand forecasts, including demand locally served by the dispersed RES production for 2020-2030. These forecasts include the demand for island interconnection from the first year of full operation of the interconnection. From 2021 and 2025 onwards, the demand for Crete and the Western Cyclades is included, respectively. Also, from 2028 and 2029 the demand for the Dodecanese and the North Aegean islands is included, respectively.

The National Energy and Climate Plans (NECPs) scenario reflects the objectives set out in the Regulation (EU) 2019/2018 based on the cases described that serve as key parameters in the development of electricity transmission systems. The increased demand scenario has been configured with estimates based on the available historical data on demand and published forecasts prepared by other competent bodies about medium-term GDP growth, long-term demand forecasts, etc.

Based on the NECPs scenario, the total energy demand is expected to grow by 14.2% from 53,200 GWh in 2020 to 60,730 GWh in 2030. In the increased demand scenario, the total energy demand is expected to grow by 22.8% from 53,870 GWh in 2020 to 66,160 GWh in 2030.

Table 2-3 Scenarios for the evolution of total energy demand

Scenario	NECPs	Increased
Year	GWh	
2020	53200	53870
2021	54320	56310
2022	54100	56900
2023	55830	59300
2024	56200	59900
2025	57000	60850
2026	57150	61460
2027	57280	61980
2028	58940	64510
2029	60080	65540
2030	60730	66160
% Δ	**14.2%**	**22.8%**

Source: ADMIE (2019)

In recent years, Greece has implemented, under unfavorable conditions, structural reforms in the energy sector. Further, the country has developed a sustainable development strategy to increase the manufacturing and the primary sector contribution, exports, productivity, and competitiveness. Greece supports and promotes the strengthening of consumers' role in the energy market. This approach may lead to the creation of new jobs and the development of innovative technologies and applications with a significant impact on energy communities (Ministry of Environment and Energy (2019).

The national energy and environmental targets for the period 2021-2030 are present in Figure 2-2.

Figure 2-2 National energy and environmental targets for 2021-2030

Greenhouse emissions reduction and environmental objectives

- emissions to sectors outside the trading system emissions rights to be reduced by at least 16% in relation to the 2005 and not exceed 54 Mt CO_2 eq.
- Emission reductions compared to 2005 for sectors within the trading system emissions rights to achieve a reduction by at least 43% compared to 2005 and not to exceed 41 Mt CO_2 eq.
- achieving quantitative objectives to reduce national emissions of specific atmospheric pollutants

Increase participation of RES in energy consumption

- share of RES in gross final energy consumption to rise at least to 31%
- share of RES in gross final electricity consumption to rise at least to 55%
- share of RES for heating and cooling needs to exceed 30%
- share of RES in transport services to exceed 14% in accordance with the relevant methodology calculation of the EU

Achieve energy savings in the final consumption

- final energy consumption not to exceed the 18.1Mtoe in 2030
- primary energy consumption energy not to exceed 25 Mtoe in 2030
- to achieve at least 7 Mtoe of cumulative energy savings in the period 2021-2030
- to ensure an annual energy base renovation of 3% of the total area of the thermal zone of the central public administration buildings by 2030

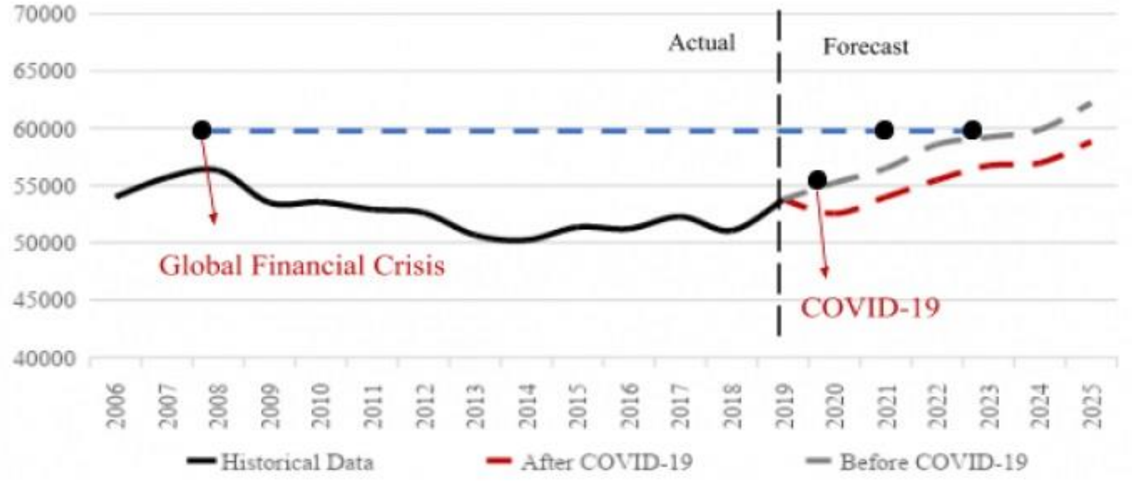
Source: Ministry of Environment and Energy (2019)

2.1.2 The COVID-19 effect on the Greek energy market

Greece is the second most expensive European country in the wholesale electricity price following Poland. According to HAEE (2020), electricity prices increased in 2018, yet the COVID-19 pandemic has completely changed the scenery. At this early stage of the COVID-19 crisis, it is quite difficult to calculate or even assess the devastating effect that the pandemic is expected to have on global energy markets. However, the implications of the pandemic are evident in three areas, namely energy security, electricity security, and resilient energy systems, and clean energy transitions. In Europe, the global lockdown measures led to a 57.0% decrease in oil demand while road transport declined between 50% and 75% (IEA, 2021).

All energy commodities have been adversely affected by the huge decline in both demand and supply. In line with most countries worldwide, Greece announced a special quarantine regime with a significant impact on economic growth. The announcement of restrictive measures, in mid-March 2020, had a direct impact on the fall in overall electricity demand. This downward trend continued until the end of April, with the maximum decrease seen during Holy Week, where the total electricity load fell by 32.4% and 35.5% compared to the corresponding levels in 2018 and 2019 (Andriosopoulos et.al. 2020) (Figure 2-3).

Figure 2-3 Evolution of total demand for electricity in Greece (GWh) before and after COVID-19



Source: Andriosopoulos et.al. (2020)

The severe decline confirms the correlation between economic activity and total electricity consumption (Hirsh and Koomey, 2015). In this context, the sharp decline in electricity demand indicates the expected fall in overall economic activity which is likely to reach alarming levels Despite the fact that 2019 has been on an upward trajectory, total electricity demand in Greece is expected to reach pre-coronavirus levels by the end of 2021.

Considering the case of the Greek energy market, the government has announced a plan aimed at acting as a guaranteed mechanism for energy suppliers, with the aim of safeguarding the sector from possible future liquidity crises. Overall, total energy consumption is expected to recover in 2021. The decrease observed in 2020 is due to the decrease in overall demand for natural gas and oil. According to current forecasts, over a two-year horizon, energy consumption will return to the levels of previous forecasts included in the National Energy and Climate Plan.

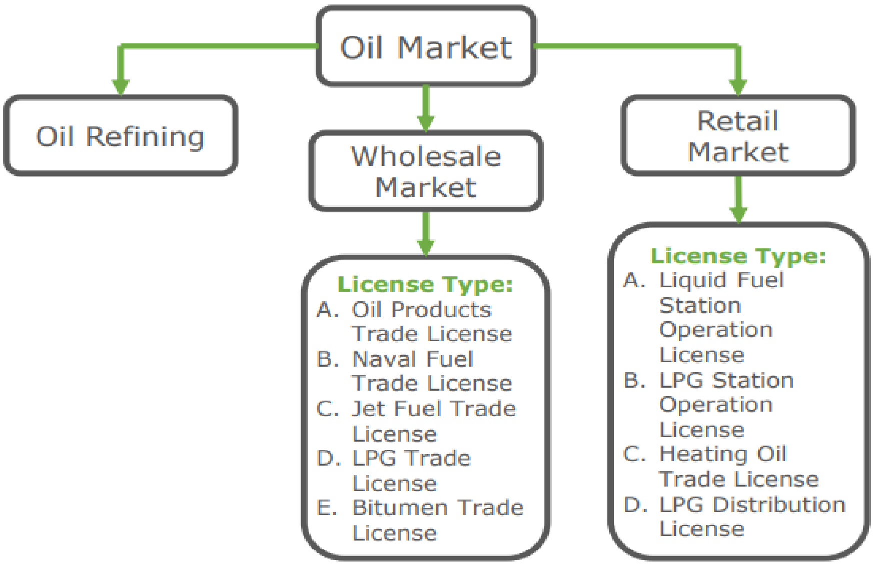
2.1.3 Oil and Petroleum Products

The oil sector is affected by the international economic and political environment which has an impact on daily oil production and consumption (Humbatova and Hajiyev). It is commonly accepted that petroleum products are necessary for all activities of economic and social life. Being an important development determinant for most countries internationally, the oil market is one of the most important sectors of the Greek economy.

The Greek oil market is divided into three sectors (HAEE, 2020):

a) Refining market: refineries buy crude oil and sell petroleum products to wholesalers.
b) Wholesale market: companies sell fuel to service stations.
c) Retail market: service stations sell fuel to consumers.

Figure 2-4 Structure of the Greek oil market



Source: HAEE (2020)

Hellenic Petroleum (HELPE) and Motor Oil are the two dominant refining companies in Greece. HELPE holds a market share of approximately 65% and operates three refineries in Aspropyrgos, Elefsina, Thessaloniki. The Group's storage capacity for crude oil and petroleum products reaches 6.65 million metric cubes (HELPE, 2021). Regarding the Nelson Complexity Index (NCI), which accounts for types of petroleum products an oil refinery can produce, HELPE produces sophisticated and complex products in Elefsina refinery, followed by Aspropyrgos, and Thessaloniki. Motor Oil refinery in Corinth has a daily refining capacity of 185 Kbpd and produces sophisticated and complex products with NCI 11.5 (Table 2-4).

Table 2-4 Technical characteristics of HELPE and Motor Oil refineries

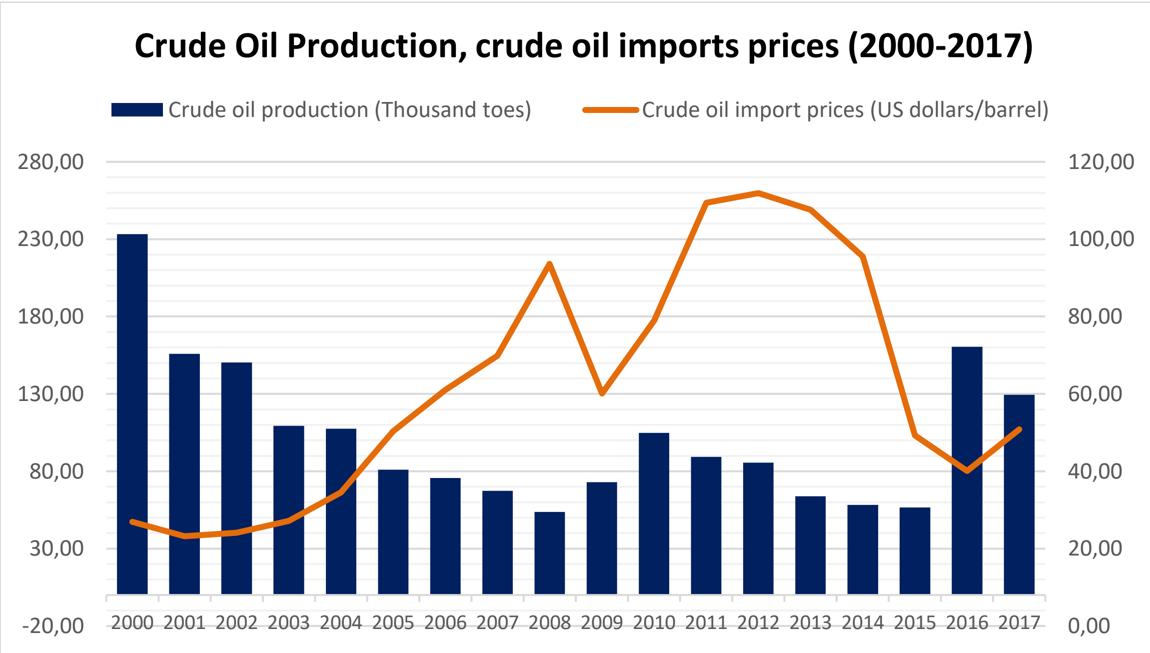
Refinery	Daily Refining Capacity (in Kbpd)	Annual Refining Capacity (in MTmm)	Refinery type	NCI
Aspropyrgos	148	7.5	Cracking (FCC)	9.7
Elefsina	100	5.0	Hydrocracking	12.0
Thessaloniki	93	4.5	Hydroskimming	5.8
Corinth	185	2.5	Hydrocracking, Catalytic	11.5

Source: HELPE (2021), Motor Oil (2021)

Between 2000 and 2017, the crude oil production in Greece decreased from 233.31 thousand toes to 129.42 thousand toes (-44.5%) with increased fluctuation in the years between. A sharp decrease can be noted between 2000 and 2008, from 233.31 thousand toes to 53.77 thousand toes (-77.0%) followed by an increase of 94.9% until 2010 to 104.81 thousand toes. Between 2010 and 2015, the crude oil production decreased from 104.81 thousand toes to 56.51 thousand toes (-46.1%) and increased by 183.8% in 2016 to 160.40 thousand toes to decrease by 19.3% in 2017 to 129.42 thousand toes (Figure 2-4).

The crude oil import prices increased by 88.8% between 2000 and 2017, from 26.90 USD/barrel to 50.80 USD/barrel. From 2000 to 2008, the increase is 248.0%, from 26.90 USD/barrel to 93.60 USD/barrel, followed by a decrease of 15.6% to 79.00 USD/barrel in 2010 and an increase of 41.6% to 107.60 USD/barrel in 2012. From 2012 onwards, the crude oil import prices decreased to 40.10 USD/barrel in 2016 (-64.2%) and increased to 50.80 USD/barrel in 2017 (+26.7%) (Figure 2-5).

Figure 2-5 Crude Oil Production, crude oil imports prices (2000-2017)



Source: OECD (2021)

According to Danchev and Maniatis (2014), the financial crisis of 2008-2009 and the following recession both in Greece and in the Eurozone have had catalytic consequences on the Greek refinery sector. At the same time, the fluctuations in the domestic and global financial environment have led to higher costs of crude oil supply, higher financing and energy costs, and lower margins. However, the Greek economy remains an "oil" economy as oil plays an important role in shaping trends and developments in the size of the Greek economy, affecting fundamental sectors, such as transport, industry, agriculture, and services.

The wholesale shipping trade is a significant section of the oil and petroleum supply chain and has a notable impact on the economy. However, due to the COVID-19 pandemic, shipping companies faced a sudden and sharp decline in shipping demand. Consequently, lockdowns and quarantine measures influenced freight rates and the profitability of shipping companies. For example, in the dry bulk segment, average daily earnings in the first semester of 2020 (Q1 2020) were down by 85% for capsizes, -40% for Panamaxes, and -35% for Supramaxes compared to Q1 2019 (Hellenic Shipping News, 2020).

Products and the processes that make up the oil circuit influence the following areas:

- Trade balance: oil products are significant contributors to the energy balance of a country.
- The smooth functioning of the oil industry and the transportation industry.
- The adequate fuel supply of all geographical sections of a country, in particular islands and mountain areas.
- Price formation as the cost of goods and services depends in part on fluctuations in fuel prices.
- The direct financial burden on households.
- The National Defense, which during crises must have the necessary fuel stocks.

Meeting the above socio-economic needs is linked to different approaches concerning the role of the public and private sector on price control, high value-added investments (petrochemicals, lubricants), investments related to environmental protection, employment, and so on.

2.2 Electricity

The electricity market in Greece operates on the mandatory wholesale pool system model. Based on this model, all transactions in electricity and complementary products carried out by participants relate to the following day. Also, all participants are required to join the consortium, while physical bilateral transactions between participants are prohibited.

The participants are the following:

1. Producers & Self-Producers

Producers shall hold a production authorization for production units entered in the register. Self-producers are licensed to produce electricity for their own use and inject excess energy into the system.

2. Suppliers

Suppliers hold a supply license that buys energy directly through the Daily Energy Planning to meet the requirements of their customers.

3. Importers

Importers hold a supply license or marketing authorization to procure quantities of energy from external producers or suppliers and inject those quantities into the Daily Energy Planning.

4. Exporters

Exporters hold a supply license or a production license or a marketing authorization, to procure quantities of energy from the Daily Energy Planning with the aim to export these quantities to other countries.

5. Customers

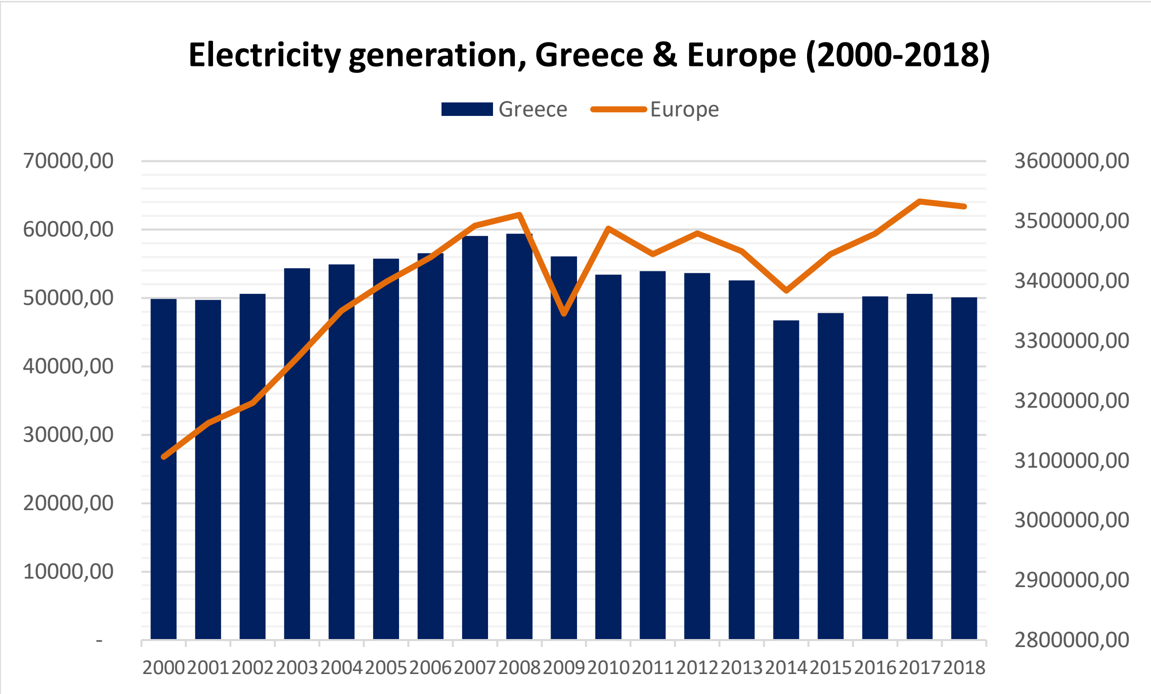
The chosen customers are electricity consumers, who have the right to choose their supplier.

In summary, producers and importers sell their produced and imported energy, respectively, on the wholesale market while suppliers and exporters purchase energy from the Daily Energy Planning and resell it to the retail market (customers) or export it, respectively.

During the COVID-19 crisis, the average daily electricity prices dropped to €27.5 per MWh in mid-April 2020 due to strict mobility restrictions imposed by the government. This price is considered particularly low for an average monthly price in Greece, as the usual variation in electricity prices ranged from 40 to 60 €/MWh in 2018 and 2019 (Andriosopoulos et al., 2020). Despite the sharp fall in electricity prices, a comparison between different EU countries reveals that in April 2020, Greece had the second-highest electricity price among European countries. This is mainly due to variations in the energy mix for electricity generation (HAEE, 2020).

Between 2000 and 2018, electricity generation in Greece increased by 0.44%, from 49,863 Gigawatt/hours to 50,084 Gigawatt-hours as opposed to the increase in Europe (+13.46%). A sharp increase can be seen between 2000 and 2008 (+19.1%) from 49,863 Gigawatt/hours to 59,407 Gigawatt/hours, but then a downward trend is dominant leading to a -21.4% decline to 46,702 Gigawatt/hours in 2014. Through 2018, the trend is upward to 50,084 Gigawatt/hours (+7.2%) (Figure 2-6).

Figure 2-6 Electricity generation, Greece & Europe (2000-2018)



Source: OECD (2021)

2.2.1 Legislative framework and Fair Energy Transition

Since 2009, the European Union has set energy and climate targets for 2020, including a 20% reduction in greenhouse gas emissions (GHG), leading to +20% in renewable energy and +20% in energy efficiency. Following the 2015 Paris Climate Agreement, the EU leaders committed to a 40% GHG reduction by 2030. In 2016, the Commission proposed the “Clean Energy Package for all Europeans” to address (1) energy security; 2) energy efficiency; 3) the internal energy market; 4) decarbonization of the economy; and 5) research, innovation, and competitiveness. More specifically (European Commission, 2019):

1. **Energy performance in buildings**

In the EU, buildings account for about 40% of energy consumption and 36% of CO_2. To improve energy performance in buildings, the EU introduced Directive EU 2018/844[6], which summarizes detailed measures for the building sector following an update on Directive 2010/31/EU.[7]

2. **Renewable energy**

Seeking to become a global leader on renewables, the EU has set a 32% target for renewable energy sources (RES) in its energy mix by 2030. Directive 2018/2001/EU[8] is in force since December 2018.

3. **Energy efficiency**

Energy efficiency is a key objective in the Clean Energy Package, given that energy savings can reduce GHG and save money for consumers. THE EU target is 32.5% energy efficiency by 2030 based on a business-as-usual scenario. Directive EU 2018/2002[9] is in force since December 2018.

4. **Energy governance**

Under the Clean Energy Package for all Europeans, each member state should draft National Energy and Climate Plans (NECPs) for 2021-2030 to present how

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[6] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L0844&from=EN
[7] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32010L0031&from=EN
[8] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L2001&from=EN
[9] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L2002&from=EN

they plan to attain the set energy union targets, especially the 2030 targets on energy efficiency and renewable energy.

5. **Increased consumer rights**

The Clean Energy Package sets more rights for consumers to produce, store or sell their own energy. Consumer rights are strengthened and protected with more transparency on bills and larger choice flexibility.

The Fair Energy Transition for All Project (2020-2022) seeks to investigate any apprehensions and anticipations related to environmentally friendly renewable energy and energy efficiency. Clean energy is a drastic transformer of any economy as it contributes to the reshaping of the energy sector and the transport, industry, and building sectors. Also, it creates "green" jobs by investing in making European energy transition socially sustainable (Fernandes and Pellerin-Carlin, 2019)

The Project has two main objectives (European Policy Center 2021):

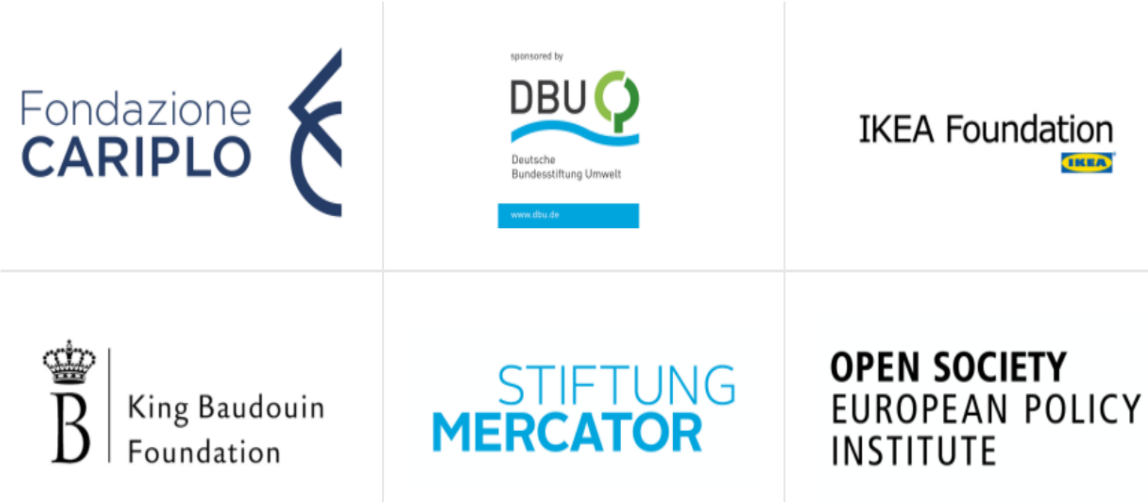
1. To understand the expectations and concerns of economically and socially disadvantaged citizens regarding energy transition by inviting citizens from nine EU countries to share their expectations on the impact of the energy transition on their lives.
2. The interviews with the target group will provide input to national and European policymakers, scientists, and stakeholders to develop fair energy transition policies.

The European Policy Center (EPC) collects the recommendations of the national policy experts regarding energy transition. The EPC has also established an EU Task Force to monitor progress and a European transition support fund to finance all structural changes brought because of the energy transition.

The main reason for launching the Fair Energy Transition for All is that global warming is a reality that no one can ignore. Currently, the way energy is produced accounts for more than 80% of total greenhouse gas emissions. In this context, energy transition represents a shift from producing energy with fossil fuels to energy production using sustainable energy sources. Implemented policies will likely influence housing, energy, transport, and other aspects of everyday lives. Effective implementation of the Project requires concrete policy recommendations and solutions (Fair Energy Transition, 2021).

The consortium of European partners in the Fair Energy Transition Project is coordinated by The King Baudouin Foundation (Figure 2-7).

Figure 2-7 Partners in the Fair Energy Transition Project



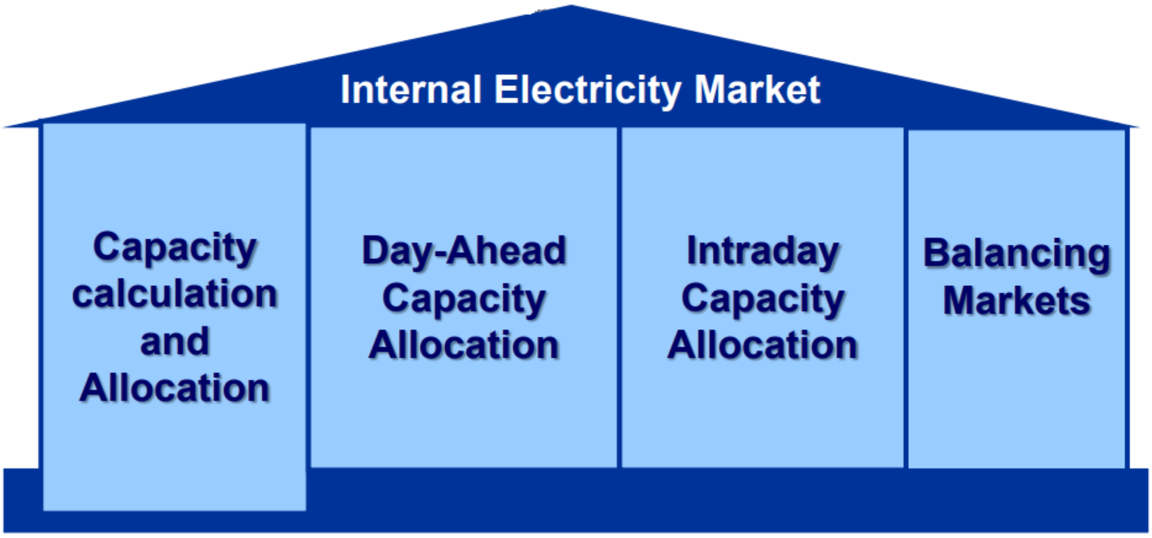
Source: Fair Energy Transition (2021)

2.2.2 The Target Model

Following three successive waves (1996, 2003, and 2009) of energy liberalization, the European Union created an integrated energy market. The creation of the single European electricity market aims to increase competition and market liquidity, thereby reducing prices at European level and total energy costs for consumers. Infrastructure projects and interconnections also play an important role in this direction, aiming at the unrestricted flow of electricity from low-priced areas to higher-priced areas, thus helping to reduce energy costs through price convergence (Pollitt, 2019).

The EU has vigorously promoted the single market for energy since 1996. Today, the single market has replaced national and cross-border electricity markets by setting out institutional changes that led to market integration. The European liberalization process aims to achieve competitive prices through the market forces and establish a unified energy market to ensure secure energy supplies (Glachant and Ruester, 2014). The creation of an integrated single European energy market aims to overcome the locality of electricity markets without lifting national Capacity Mechanisms. The aim is for the supply and, therefore, the price of electricity to be formed across borders within a framework that considers international interconnections (Hawker et al., 2017). In this context, the Target Model is implemented within the Internal Electricity Market framework (Figure 2-8).

Figure 2-8 Internal Electricity Market



Source: Argyriou (2014)

At the Union level, the main text now governed by the Target Model is Regulation 2019/943[10] on the internal electricity market. In Greece, the Target Model is integrated at a national level with Law 4425/2016.[11] Put simply, domestic demand should consider energy supply through imports from the other Member States, and the markets of the other Member States should be accessible to Greek producers. This is a dynamic situation that also addresses the need for national investments to increase the capacity of international interconnections and transmission lines (HAEE, 2019).

Greece complies with a fundamental obligation to the single European electricity market that removes trade restrictions, allows the connection between national markets, and ensures access to all on equal terms. To strengthen competition

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[10] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019R0943&from=EN
[11] https://www.lawspot.gr/nomikes-plirofories/nomothesia/nomos-4425-2016 (in Greek)

and benefit the consumer, Greece has upgraded its wholesale electricity market to allow efficient price formation without distortions. In doing so, the Target Model will highlight existing market problems through appropriate price signals. Further, it can address the high demand for flexible power and increased volumes of balancing energy.

The benefits expected following the implementation of the Target Model in Greece include (Metaxas et al., 2020):

- Promoting competition.
- Greater convergence of the prices of the Greek market with neighboring countries.
- The development of a transparent framework for market costs.
- Highest quality operation of the electricity system through most efficient use of interconnections.
- Improving the liquidity of individual markets.
- Expanded access to cheaper energy sources.
- The increased ability to trade (including export) electricity from renewable energy sources.

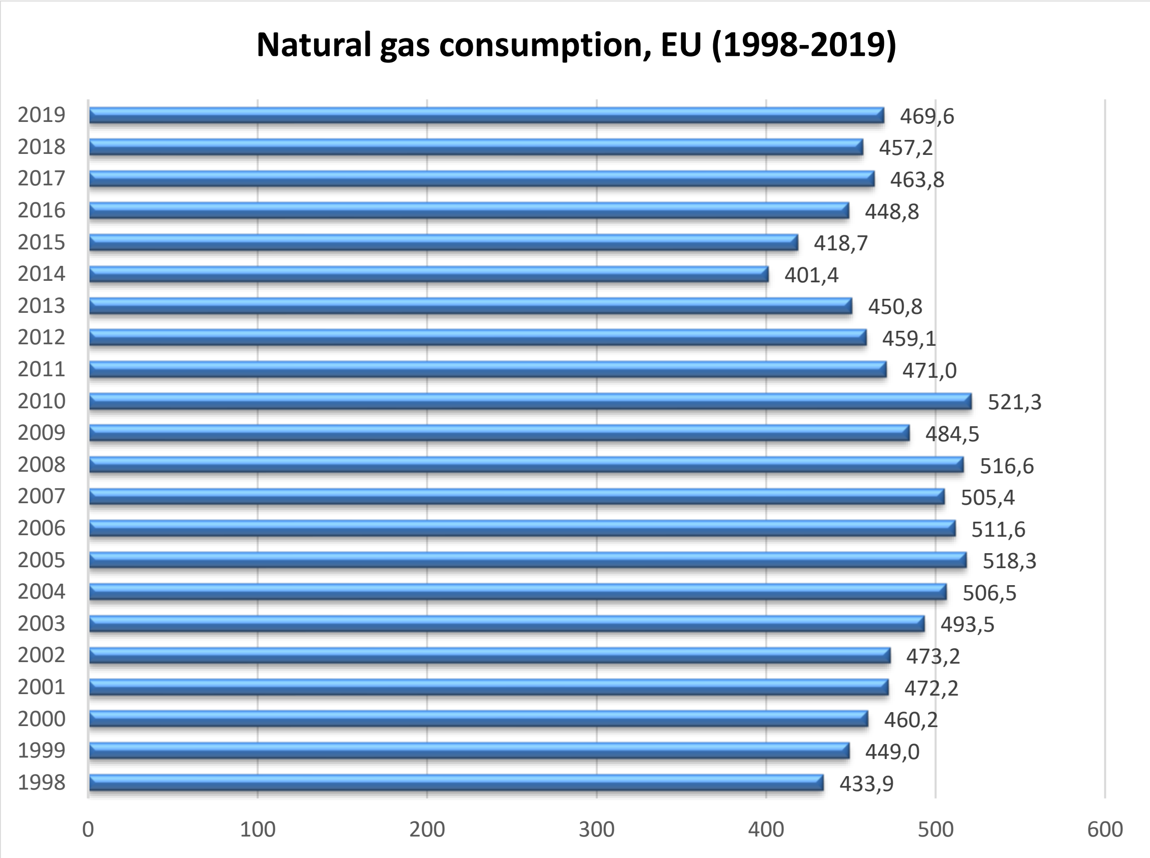
2.3 Natural gas

Natural gas use has grown rapidly internationally over the last three decades. Most European Union countries now cover a significant proportion of their energy balance with natural gas. In 2019, gross inland consumption of natural gas recorded a 4.2% year-on-year increase, reaching 15.591 thousand terajoules. According to Eurostat (2021b), the highest increase in consumption of natural gas was recorded in Spain (+14.1%), followed by Greece (+9.0 %) and Germany (+7.7 %). The highest declines are seen in Latvia (-8.4%), Estonia (-8.0%) and Denmark (-6.7%).

Between 1998 and 2019, natural gas consumption in the EU has increased by 8.2%, from 433.9 billion cubic meters to 469.6 billion cubic meters. However, the increase from 1998 to 2008 is 19.1% and to 2010 is 20.1%. Between 2011 and 2015, the natural gas consumption in the EU decreased by -11.1% from 471.0

billion cubic meters to 418.7 billion cubic meters and slowly increased to 469.6 billion cubic meters (Figure 2-9).

Figure 2-9 Natural gas consumption, EU (1998-2019)



Source: Statista (2021)

Natural gas is distributed through a gas distribution networks or transported through virtual gas pipelines and can be used to generate high efficiency electricity and heat through cogeneration technology. The two form of natural gas are Compressed Natural Gas (CNG) and Liquefied Natural Gas (LNG). CNG consists largely of methane and is transported in hard cylindrical tanks at a pressure of 20-25 MPa. LNG also contains mainly methane, concentrated in liquid form, and cooled to -160 degrees Celsius. LNG is transported at a pressure of 25kPA.

The use of natural gas in electricity production in Greece absorbs more than 2/3 of the total primary available quantity of natural gas. The rest is consumed by various industries, the service sector, the households, and the transport sector.

Between January and June 2020, natural gas occupied the largest share in Greece's net electricity generation mix (44.8%), followed by RES 35.7%, Lignite 13.9%, Hydro units 5.6% (Table 2-5).

Table 2-5 Sources of net energy production in Greece (Jan-Jun 2020)

	Gigawatt hours	%
Natural gas	8,036.30	44.8%
RES	6,400.20	35.7%
Lignite	2,494.30	13.9%
Hydro units	1,001.70	5.6%
Oil	0.40	0.0%
Total	**17,932.90**	**100.0%**

Source: Statista (2021a)

In April 2021, the European Commission adopted new rules on which energy infrastructure will be accepted as "green" for funding. The EU Taxonomy Climate Delegated Act is a *'strong, science-based transparency tool for companies and investors and creates a common language for investing in projects and economic activities with a substantial positive impact on the climate and the environment.'* The focus of the gas sector is on the requirements requested by the Commission so that the specific projects (pipelines, LNG, units) can receive the appropriate credentials and financing. According to the latest Commission proposal under discussion, there is the option to replace older coal units with new gas plants, provided the replacement takes place through 2025 (European Commission, 2021b).

2.4 Renewable Energy Sources (RES)

Renewable energy is a natural energy that cannot be exhausted and is generated from natural resources that can be found on the earth's surface and be converted into a workable structure. The environmental behavior of renewable energy sources is different from petroleum or other non-RES as they are not polluting the environment (CRES, 2021).

The Energy Roadmap for 2050 (European Union, 2012) lays down certain conditions that the EU members should meet to lower their energy sector emissions. In line with these long-term plans, Member States should comply with:

1. Setting immediate priority in achieving the 2020 targets, by implementing all measures designed for this.
2. The energy system and society should become active and more energy efficient.
3. Emphasizing the penetration of RES.
4. Promoting technological innovation is crucial in the commercialization of new technologies.
5. Protecting vulnerable consumers and avoiding energy poverty.
6. Developing new energy infrastructures and storage capabilities.
7. Taking global initiatives in the security of energy sources
8. Coordinating European action in international relations to strengthen the efforts for international climate actions.

According to the EU Directive 2001/77/EC[12], the main Renewable Energy Sources are "solar energy, wind energy, wave energy, tidal energy, biomass, gases released from landfills and landfills of biological purification, biogases, geothermal energy, and hydraulic energy used by hydropower plants."

Solar energy is used for generating electricity, heating and lighting, solar cooling, and various commercial and industrial uses. Also, solar energy is the most efficient for providing clean, safe, and dependable power as it is more than 200 times the total annual commercial energy currently used by humans (Alrikabi, 2014).

Wind energy is a renewable energy source that can meet electricity needs based on exploitation technology. Modern wind power systems mainly concern wind turbines that convert wind energy into electricity. Wind turbines are connected to the power transmission network and established in windy areas. Alternatively, wind turbines may operate autonomously with mechanical energy for use in

[12] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32001L0077&from=EN

pumping stations or heat, but in this case, their economic importance is limited (GE Renewable Energy, 2021).

Wave energy is the energy of the waves that move regressively and can be used to rotate wheels with fins and then generate electricity. Tidal energy is produced by the periodic rise and fall of the water level of the sea. Tidal currents are energy-efficient and move water masses at a remarkable speed. These currents develop near bays and coves that favor their formation, thereby creating a significant tidal range. The technologies used to convert tidal energy into electricity are special generators, turbines, and paddles (National Geographic, 2021).

Biomass energy is generated by living or once-living organisms and a source for energy production supplied by agriculture. Today, mainly corn and soy are used for biomass production to generate heat, electricity, or biofuel (National Geographic, 2021).

Biogas usually refers to a mixture of different gases produced by the decomposition of organic matter in the absence of oxygen. Biogas is produced from raw materials such as agricultural waste, manure, municipal waste, plant matter, bogs, green waste, or food waste. It is a renewable energy source and uses a small carbon footprint. Advanced waste treatment technologies can produce biogas with 55%–75% methane, which for free-liquid reactors can be increased to 80%-90% methane using on-site gas purification techniques (EBA, 2021).

Geothermal energy is the heat contained inside the earth and is so large that it can be considered a practically inexhaustible form of energy for human measures. Geothermal energy applications include energy generation, heating, cooling, air conditioning, antifreeze protection, fish farming, etc. (ThinkGeoenergy, 2021).

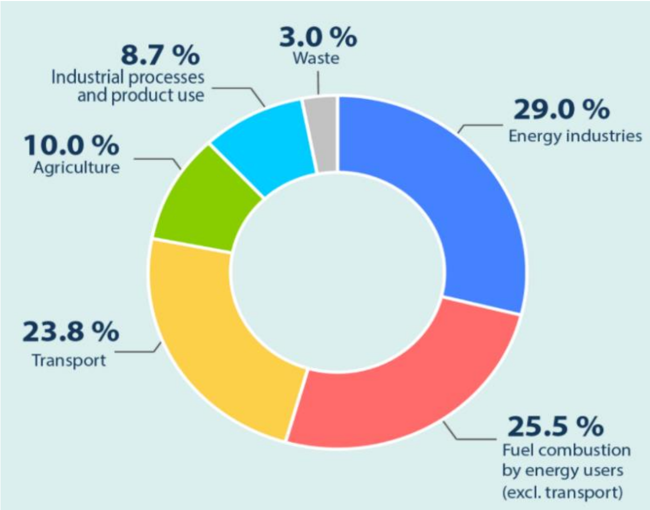
2.5 Energy Efficiency and Co-production

Energy efficiency is the elimination of energy waste by reducing greenhouse gas emissions (GHG), lowering demand for energy imports, and cutting energy costs, both on households and an economy-wide level. Among RES, energy efficiency is the cheapest and fastest way to reduce the use of fossil fuels, and it can apply to buildings, transportation, community design, ships, vehicles, and so on (EESI, 2021).

Regarding EU greenhouse gas emissions, member states have achieved a 24.0% reduction in the period 1990-2019 with a 60% growth in the EU economy. Of 24.0%, 9.1% was achieved in the period 2018-2019 in power plants unlike transport, buildings, agriculture, and waste that remained unchanged. Also, CO2 emissions from aviation rose by 3.0% in 2019. The target is to reduce EU GHG by at least 40% through 2030 (European Commission 2021c). The main sources of GHG in the EU are energy industries (29.0%), fuel combustion (25.5%) and transport (23.8%), followed by agriculture (10.0%), industrial processes and product use (8.7%), and waste (3.0%) (Figure 2-10).

In Greece, energy efficiency is one of the important environmental issues managed by PPC, seeking to boost primary energy consumption without reducing production activity. PPC implements measures to improve energy efficiency in accordance with Directive 2004/8/EC[13] and Directive 2006/32/EC[14] to promote energy efficiency and cogeneration of energy in the EU internal energy market and Greece, respectively.

Figure 2-10 sources of greenhouse gas emissions in the EU, 2017



Source: Eurostat (2021)

[13] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32004L0008&from=EL
[14] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32006L0032&from=EN

In the context of measures to improve energy efficiency in energy supply, PPC:

- Has completed actions to upgrade and modernize its existing units.
- Through PPC's cooperation programs with the competent Municipal Enterprises of the Energy Municipalities, the heat generated by steam power plants in Western Macedonia and Arcadia is used to provide thermal energy and meet the heating needs for urban use in Kozani, Ptolemaida, Amyntaio, and Megalopolis in the context of sustainable energy management.
- Has implemented an investment program to replace obsolete thermal units with new, environmentally friendly, modern technology and higher efficiency units in Aliveri with natural gas fuel (58% efficiency), Megalopolis (57% efficiency), and Ptolemaida (steam power plant with powdered lignite fuel (41.5% efficiency).
- Provision of the electrical interconnection of the Cyclades, which will lead to significant savings in primary energy.

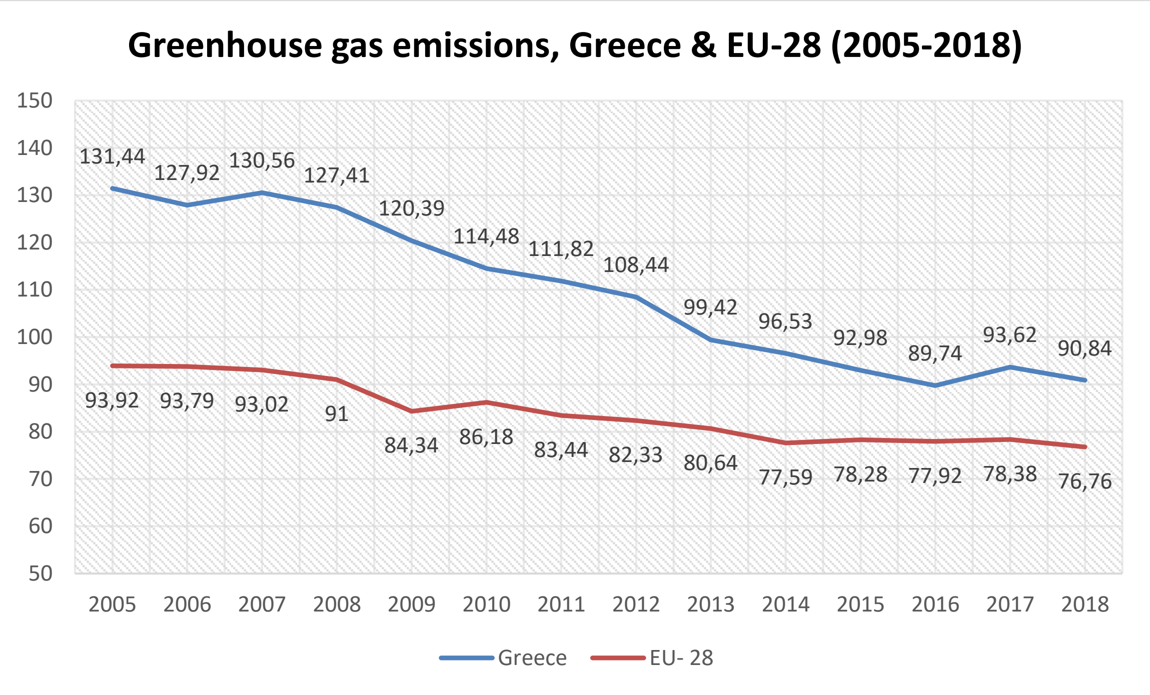
In the context of measures to improve energy efficiency in energy use, PPC:

- Implements an energy efficiency improvement program in two of its office buildings that house public service services within the framework of the European Energy Upgrade and Certification Programme for Green Building
- Records energy consumption in PPC buildings.
- Continues upgrading the energy class of the air conditioners in line with the new energy efficiency regulation of buildings.
- Computer workstations (5,000) are put into sleep mode to reduce energy.

PPC participates in the ENERGY WISDOM environmental program of EURELECTRIC to promote actions that improve energy efficiency and in the World Business Council for Sustainable Development (WBCSD) to promote sustainable development.

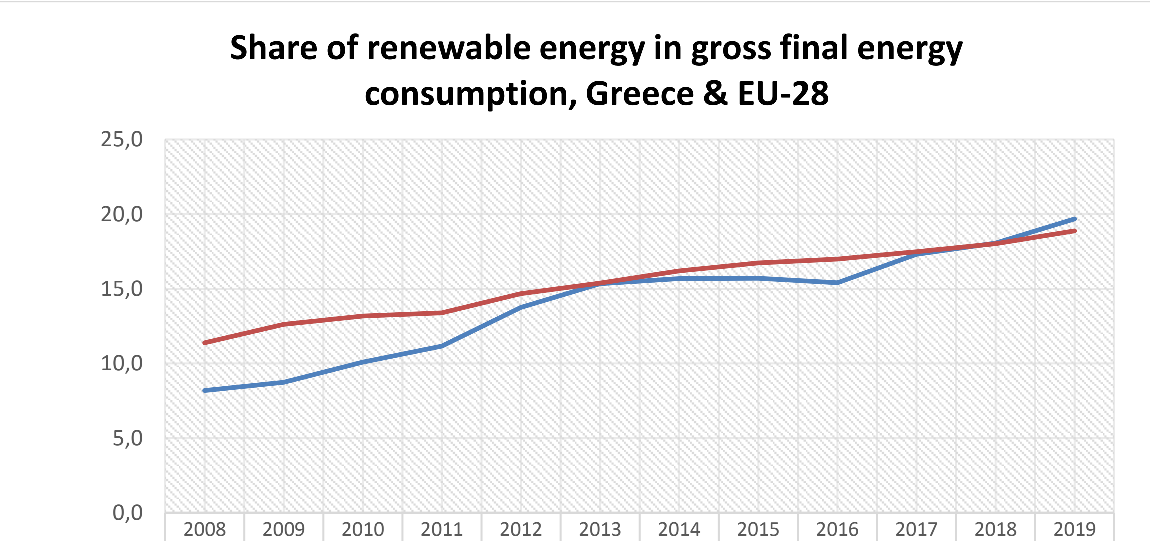
GHG emissions in Greece are significantly higher than the EU average between 2005 and 2018 (Figure 2-11). Renewable energy (% gross final energy consumption) is lower than the EU average from 2008 to 2017, but then it exceeds it (Figure 2-12).

Figure 2-11 Greenhouse gas emissions, Greece & EU-28 (2005-2018)



Source: Eurostat (2021a)

Figure 2-12 Share of renewable energy in gross final energy consumption, Greece & EU-28 (2008-2019)



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Greece	8,18	8,73	10,08	11,15	13,74	15,33	15,68	15,69	15,39	17,30	18,05	19,68
EU- 28	11,38	12,62	13,16	13,39	14,66	15,37	16,20	16,73	16,98	17,48	18,01	18,88

Source: Eurostat (2021a)

Cogeneration refers to the combined production of electricity and heat from the same initial energy source. In the conventional way of generating electricity, large amounts of heat are discharged into the environment, either through the cooling circuits (condensers, cooling towers, etc.) or through the exhaust gases (air turbines, etc.). By the cogeneration method, a significant part of this heat is recovered and used beneficially. Gas power stations and electric-hear cogeneration systems are the best possible choice regarding energy savings, production costs, and environmental impacts. Natural gas is used in large power plants and for the cogeneration of energy in industries and buildings (DEPA, 2021).

In Greece, the recent cogeneration plants were created in the early 1970s in the industrial sector, without any state financial assistance. All the co-producers were self-producers, and the main fuels were oil or petroleum products whereas, two small pilot cogeneration units were installed in the tertiary sector, subsidized by European programs. In 1985, the installed capacity of electric-heat cogeneration in various industrial sectors was 346.3 MWe, of which 93.5 MWe (27%) in refineries, 80 MWe (23%) in steel industries, 56 MWe (16%) in food industries, 48 MWe (14%) in chemical industries, 43 MWe (12%) in paper industries, 14.5 MWe (4%) in textiles, and 11.3 MWe (3%) in aluminum.

At the beginning of the 21st century, electric-heat cogeneration improved through Law 2773/99[15] and fuel supply security. The installed capacity of electric-heat cogeneration in 2005 was 168.16 MWe, of which 93.5 MWe (56%) in refineries, 11.3 MWe in aluminium (7%), 11 MWe (7%) in the chemical industry, 4.5 MWe (3%) in the food industries, and 3 MWe (2%) in metal industries (Theofylaktou, 2020).

From 2010 to 2019, the annual energy production from all cogeneration units increased from 115.0 to 186.5 GWh (+62.2%) while from 2013 to 219, the annual energy production from allocated cogeneration units decreased by 7.1% from 943.0 to 876.0 GWh. The total production from RES and cogeneration units increased from 3,256.50 to 13,357.5 (+310.2%). Finally, the share of electric-

[15] https://www.iea.org/policies/4046-law-277399

heat cogeneration in total production decreased from 3.53% to 1.40% (Table 2-6).

Table 2-6 Annual energy production - cogeneration units and RES (2010-2019)

	Annual energy production from all cogeneration units	Annual energy production from allocated cogeneration units	Total production from RES & cogeneration units	% cogeneration on total production
	GWh	GWh	GWh	%
2010	115.0	0.0	3,256.50	3.53
2011	142.0	0.0	3,959.50	3.59
2012	149.0	0.0	5,406.50	2.76
2013	119.0	943.0	9,156.00	1.30
2014	159.0	1116.0	9,091.00	1.75
2015	188.0	1121.0	10,051.00	1.87
2016	185.0	1112.0	10,469.00	1.77
2017	195.0	984.0	11,552.00	1.69
2018	183.5	918.0	12,221.50	1.50
2019	186.5	876.0	13,357.50	1.40
% D	**62.2%**	**-7.1%**	**310.2%**	**-2.13**

Source: The European Energy Poverty Index (EEPI) (2019)

An interesting element of the analysis is that the percentage of electric-heat cogeneration in total production is low due to the rapid increase in RES installations in the country. Based on the information in Table 2-5, the need to promote electric-heat cogeneration in Greece is imperative for the improvement of the country's energy system.

2.6 Energy Poverty in Europe and Greece

Following the 2008 economic downturn and the global COVID-19 pandemic, energy poverty is becoming pronounced, especially in low- and middle-income households. According to the EU, energy poverty is described as the “inability to keep homes adequately warm.” In this context, the ‘Grenelle II’ Act defines energy poverty as “a situation in which a person has difficulty obtaining the necessary energy in their home to meet their basic needs because of inadequate resources or living conditions." (European Commission, 2021). Pye et al. (2015) define energy poverty as a set of conditions where "individuals or households are not able to adequately heat or provide other required energy services in their homes at affordable cost." Based on the above, energy poverty is related to the lack of benefits brought about by energy use at home.

Energy poverty addresses the complex interaction of rising energy prices, high energy costs, stagnating or falling incomes, rising unemployment, and energy inefficiency. These factors document negative social, environmental, and economic impacts (Drossou and Metaxa, 2020). Although energy poverty is not the same as income poverty, the two concepts interrelate as energy poverty is a circular process. Initially, the low-income household can afford cheap, poor-quality housing. Due to the construction and energy inadequacy of houses, the cost of energy needs is high. Households spend a large share of low-income on energy services, which rises as energy prices rise. After a while, low-income households experience energy poverty as they cannot afford to improve housing conditions. People affected by energy poverty have health problems and deteriorating social well-being. The reduction of heating and cooling hours within the houses and lower electricity consumption for lighting, lead to thermal discomfort, bad ventilation, and insufficient lighting (Horta et al., 2019).

Energy poverty is recognized globally as a social problem with increasing importance and serious effects on the health of many millions of citizens. The issue of energy poverty and vulnerable consumers is highlighted in several European directives (Directive 2009/72/EC[16] and Directive 2009/73/EC[17]), while a specific reference on energy efficiency is made in Directive 2012/27/EU.[18] Between 50 and 125 million people in European households cannot afford proper indoor thermal comfort (European Commission, 2021a). According to the European Energy Poverty Index (EEPI), Greece ranks in the 18th place among EU-28 member states regarding energy poverty alleviation (Table 2-7).

[16] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009L0072&from=EN
[17] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009L0073&from=en
[18] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32012L0027&from=EN

Table 2-7 EEPI ranking of EU-28 performance in energy poverty alleviation

Country	European Energy Poverty Index EEPI		European Domestic Energy Poverty Index EDEPI		European Transport Energy Poverty Index ETEPI	
	Rank	Score	Rank	Score	Rank	Score
Sweden	1	86.34	1	95.41	7	78.13
Luxembourg	2	83.97	5	80.88	1	87.19
Austria	3	79.58	4	81.21	8	77.99
Denmark	4	78.94	3	81.88	13	76.10
Netherlands	5	77.25	8	78.09	12	76.42
France	6	75.35	10	73.33	11	77.43
United Kingdom	7	74.98	6	80.54	16	69.79
Belgium	8	73.26	11	67.62	5	79.37
Germany	9	72.32	9	75.77	18	69.02
Spain	10	71.80	12	64.67	4	79.72
Czech Republic	11	68.99	15	60.21	6	79.05
Poland	12	64.45	14	61.01	19	68.08
Romania	13	62.40	13	64.23	20	60.63
Cyprus	14	62.27	21	46.23	2	83.90
Slovenia	15	62.05	20	51.34	14	74.99
Lithuania	16	57.42	23	42.37	10	77.82
Croatia	17	57.19	16	58.79	21	55.64
Greece	18	56.70	22	43.69	15	73.58
Ireland	19	55.86	7	79.29	25	39.35
Portugal	20	53.42	25	36.67	9	77.83
Latvia	21	52.55	24	40.01	17	69.03
Italy	22	52.09	19	52.10	22	52.08
Estonia	23	48.65	18	58.02	23	40.80
Slovakia	24	26.33	26	8.35	3	83.04
Finland	25	18.38	2	85.56	27	3.95
Malta	26	15.56	17	58.56	26	4.13
Bulgaria	27	5.30	28	0.71	24	39.55
Hungary	28	4.57	27	6.19	28	3.38

Source: The European Energy Poverty Index (EEPI) (2019)

In Greece, there is no clear quantitative definition and specific indicators of monitoring energy poverty. However, a household experiences energy poverty if it spends more than 10% of its income on its energy needs. Most related studies apply quantitative indicators and questionnaires to record energy poverty in Greece.

Dagoumas and Kitsios (2014) investigate the effect of the global financial crisis on energy poverty by monitoring electricity consumption per capita and the relationship to economic growth (GDP). Their findings suggest that the 2008 crisis has had a substantial impact on energy demand in Greece. Many households were unable to pay their bills and have initiated power cuts to decrease unnecessary spending and meet their energy needs.

Katsoulakos and Kaliampakos (2016) claim that the characteristics of mountainous areas in Greece determine energy planning and energy needs. Altitude can substantially influence energy optimization results due to its impact on energy demand. Further, spatial restrictions in mountainous areas increase energy systems' operation costs, thereby leading to energy poverty.

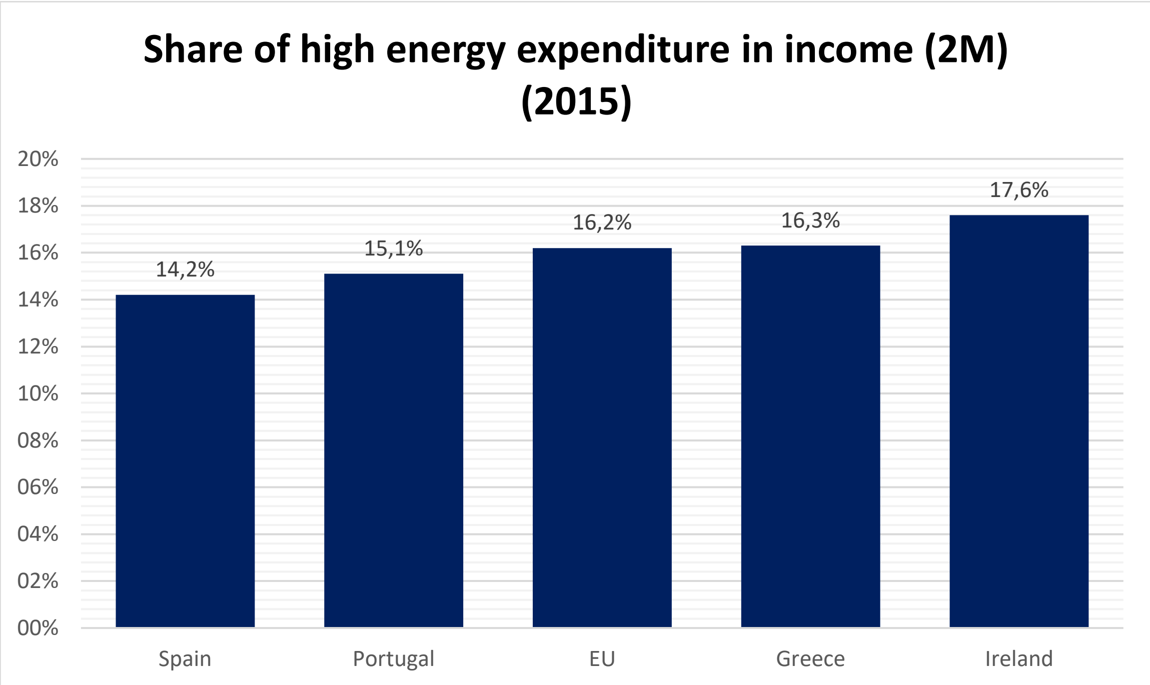
Following the 2008 financial crisis, Papada and Kaliampakos (2016) investigate the exposure of Greek households to energy poverty. Their findings show that 58% of Greek households face energy poverty while 75% of Greek households have lower other expenses to save on energy needs. On the other hand, a newer study reveals that 34.5-38% of the investigated households waste energy (Papada and Kaliampakos, 2020).

A field work by Boemi et al. (2017) identifies a range of factors that could lead a household to energy poverty. The authors find that the energy poverty dynamics in Greece relate to energy vulnerability, quality of housing, quality of the heating system, indoor thermal comfort, and the net income.

Ntaintasis et al. (2019) use a sample of 451 households to assess energy poverty in the Attica region. The authors conclude that energy poverty is not only driven by income but also by local circumstances. Their findings determine that 27.5% of households are energy poor, and 11.5% of households experience high energy poverty intensity. Evidence from 350 households in Western Macedonia and Central Macedonia confirms that the domestic energy demand is related to the household's net income as well as to regional characteristics (Boemi and Papadopoulos, 2019).

According to the EU Energy Poverty Observatory (2015), Greece's high share of energy expenditure in income (2M indicator) is in line with the EU average, 16.3% vs. 16.2% respectively. Compared to other periphery economies, Greece's share is higher than Spain's (14.2%) and Portugal's (15.1%) and lower than Ireland's (17.6%) (Figure 2-13). The 2M indicator shows the percentage of households with an energy expenditure as a percentage of income more than twice the national median share.

Figure 2-13 Share of high energy expenditure (% income) (2M) (2015)

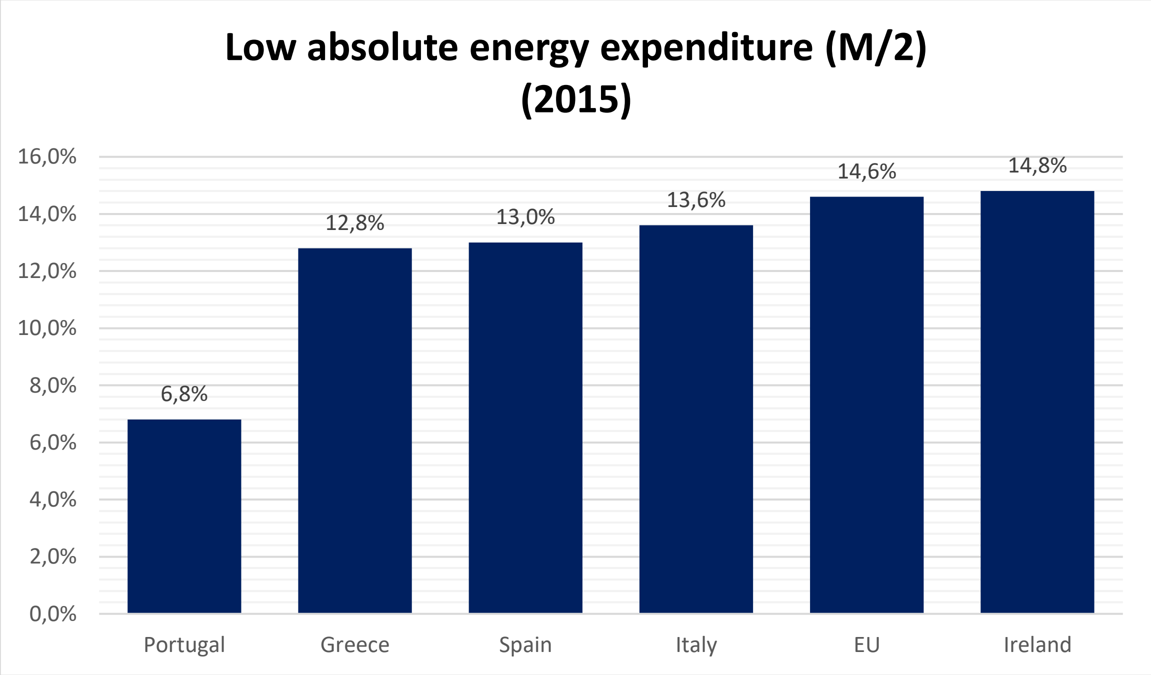


Source: EU Energy Poverty Observatory (2015)

Regarding the M/2 indicator, Greece's share is 12.8% lower than the EU average of 14.6%. Also, Ireland (14.8%), Spain (13.0%), and Italy (13.6%) have higher M/2 indicators as opposed to Portugal that has 6.8%, the lowest of the periphery economies (Figure 2-14). The M/2 indicator shows the percentage of households with an absolute energy expenditure that is below 50% of the national median.

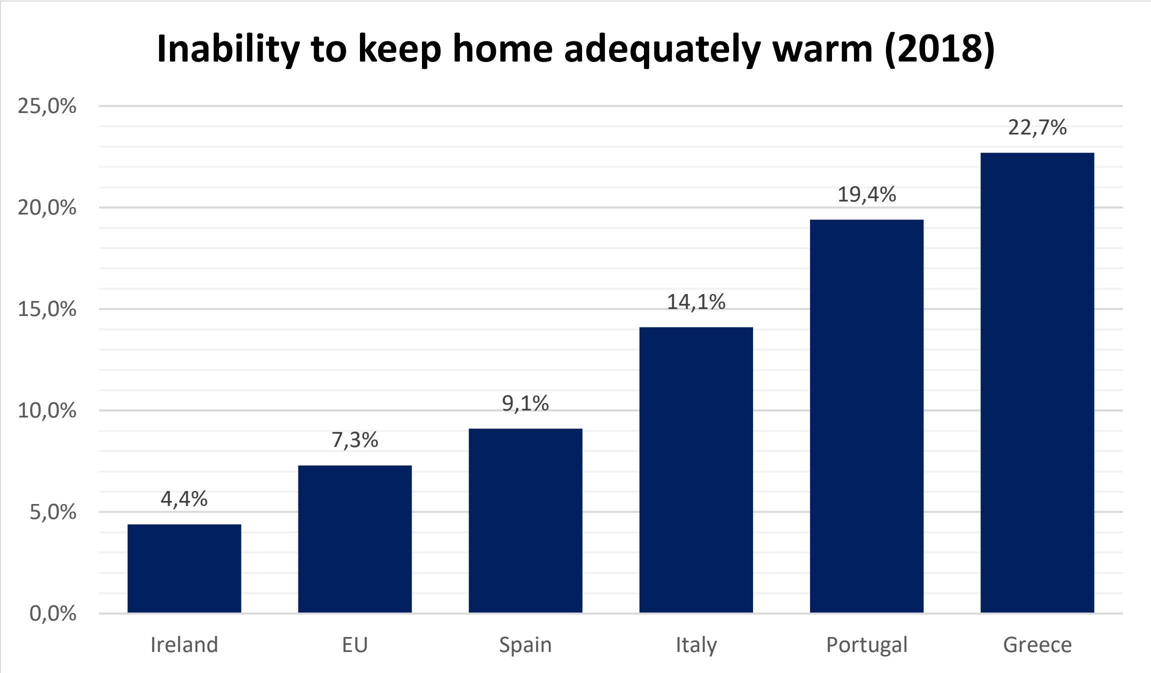
The share of population unable to keep their home adequately warm is the highest in Greece, 22.7%, followed by Portugal 19.4%, Italy 14.1%, and Spain 9.1%. Only Ireland is below the EU average, 4.4% vs. 7.3% (Figure 2-15).

Figure 2-14 Low absolute energy expenditure (M/2) (2015)



Source: EU Energy Poverty Observatory (2015)

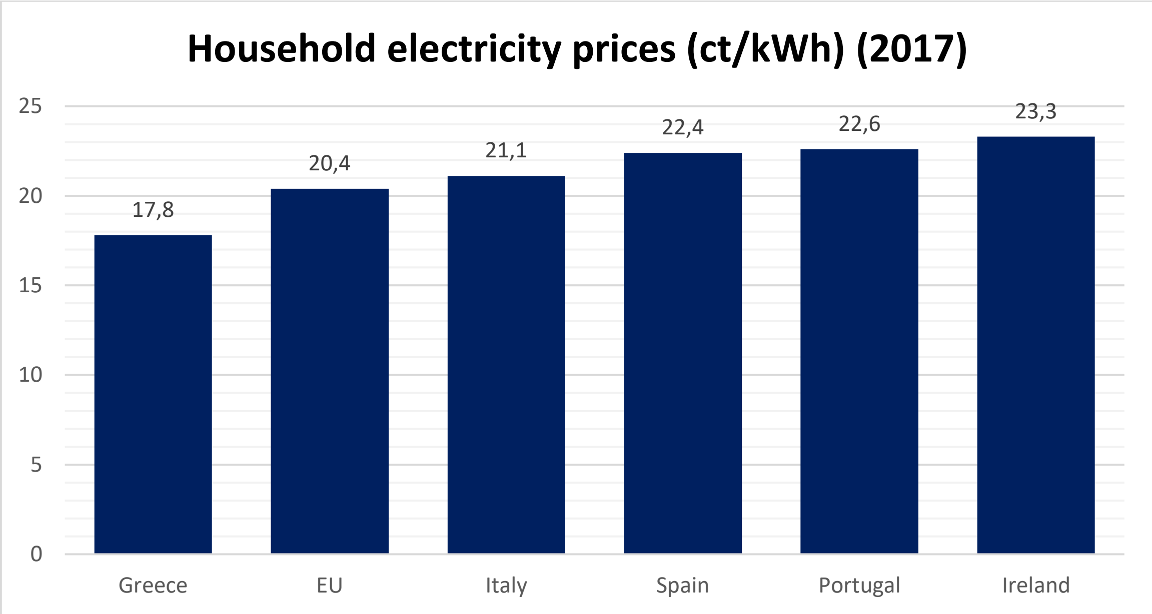
Figure 2-15 Inability to keep home adequately warm (2018)



Source: EU Energy Poverty Observatory (2018)

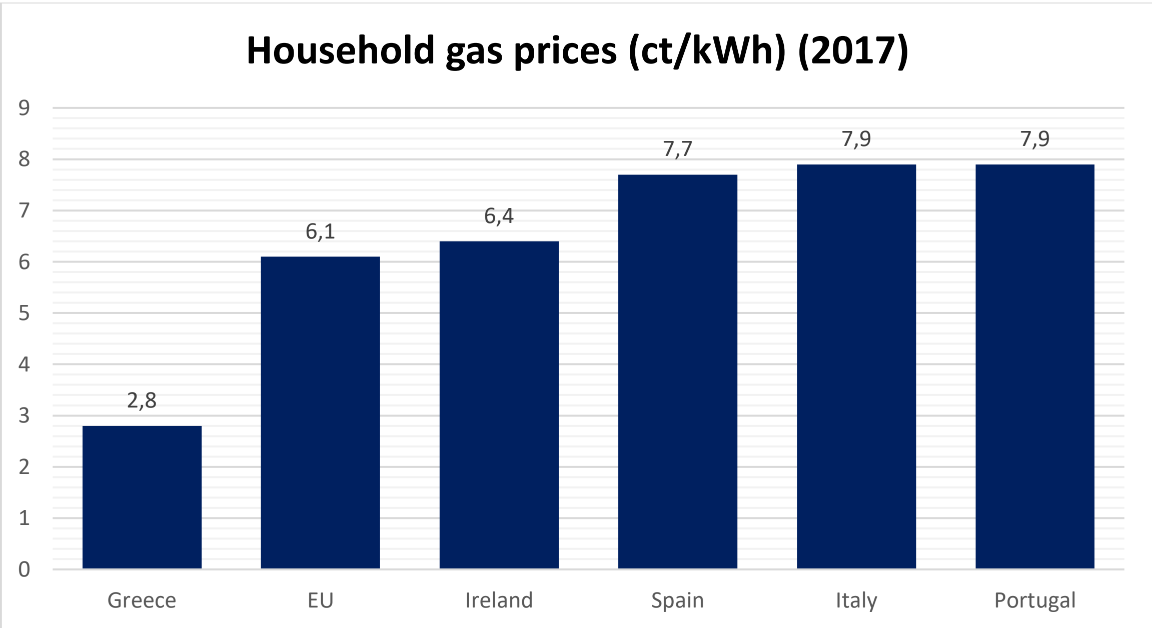
On the other hand, Greece has the lowest household electricity prices, 17.8 ct/kWh, below the EU average (20.4), Italy (21.1), Spain (22.4), Portugal (22.6), and Ireland (23.3) (Figure 2-16). Greece has also the lowest household gas prices ct/kWh (2.8), below EU (6.1), Ireland (6.4), Spain (7.7), Italy (7.9), and Portugal (7.9) (Figure 2-17).

Figure 2-16 Household electricity prices (ct/kWh) (2017)



Source: EU Energy Poverty Observatory (2017)

Figure 2-17 Household gas prices (ct/kWh) (2017)



Source: EU Energy Poverty Observatory (2017)

2.7 National Energy and Climate Plan

The National Plan for Energy and Climate (NPEC) is a Strategic Plan for Climate and Energy issues and presents a detailed roadmap for achieving specific Energy and Climate Objectives by 2030. The Greek government intends to use the NPEC as a tool in shaping national energy and climate policy through 2030, considering the recommendations of the European Commission and the UN Sustainable Development Goals (Figure 2-18).

Figure 2-18 UN Sustainable Development Goals

Source: United Nation Sustainable Development (UNSD) (2021)

The strategic goal of NPEC is to make a decisive contribution to the energy transition in the most economically competitive way for the national economy. Furthermore, to achieve a drastic reduction of greenhouse gas emissions and highlight Greece as one of the Member States that has adopted ambitious climate and energy targets through a comprehensive program of measures and policies. NPEC might place Greece at the heart of Energy Union developments for 2030 and long-term 2050. Energy transition will combine the strengthening of the competitiveness of the Greek businesses and consumer protection by establishing a sustainable development framework of the national economy. Also, it will capitalize on national and European financing mechanisms and adopt appropriate market mechanisms according to the EU legislation.

NPEC highlights the priorities and development opportunities that Greece has in terms of energy and climate change. The Plan provides specific quantitative and qualitative targets to outline Policy Priorities and Measures in a wide range of development and economic activities and address the following issues (NPEC, 2019):

- Achieving an integrated model of sustainable development in all economic sectors.
- Combining energy sector development with environmental protection with decisive measures to tackle climate change.
- Selecting energy policies with the best cost-benefit ratio for the energy transition
- Managing and utilizing waste with modern technologies of the circular economy.
- Transforming Greece into an energy hub with an important contribution to the EU energy and supply security.
- Implementing a diversification strategy in energy imports
- Creating an attractive investment environment to support the energy transition, emphasizing innovation and new technologies.
- Maximizing Community resources and mechanisms.
- Achieving extroversion and innovation for growth and job creation.
- Accelerating the electrical interconnection of the islands.
- Strengthening energy interconnections.
- Developing strategic storage projects.
- Digitalizing energy networks.
- Promoting e-mobility and new technologies
- Developing new financial instruments.

Total installed power is estimated to grow +24.6% through 2030, from 21.1 GW to 26.3 GW, with a doubled power storage capacity from 0.7 to 1.4. Gross electricity production will increase +6.5% from 54,386 GWh to 57,927 GWh and net electricity production will increase +9.2% from 52,379 GWh to 57,219 GWh. Lignite production will be fully eliminated through 2030, petroleum production will decline by 77.0% and natural gas production will decline by 20.3%. In contrast, bioenergy production is expected to increase +270.6% from 425 GWh to 1,575 GWh, water plants production will increase +21.0% from 5,453 GWh to 6,596 GWh, and photovoltaic production will increase +159.8%, from 4,548 GWh to 11,816 GWh. These increases will lower net electricity imports by 26.2% and CO2 emissions by 69.6% (Table 2-8).

Table 2-8 Key features of power generation system through 2030

	2020	2022	2025	2027	2030	% 2030 - 2020
Installed Power [GW]						
Lignite	3.9	2.9	0.7	0.7	0.0	
Petroleum (including refineries)	1.9	1.8	1.0	1.0	0.3	
Natural Gas	5.2	6.0	6.9	6.9	6.9	
Bioenergy	0.1	0.1	0.1	0.2	0.3	
Water plants (including mixed pumps)	3.4	3.7	3.8	3.9	3.9	
Wind plants	3.6	4.2	5.2	6.0	7.0	
Photovoltaic stations	3.0	3.9	5.3	6.3	7.7	
Solar thermal stations	0.0	0.0	0.1	0.1	0.1	
Geothermal stations	0.0	0.0	0.0	0.0	0.1	
Total	**21.1**	**22.6**	**23.1**	**25.1**	**26.3**	**24.6%**
Central system power storage	**0.7**	**0.7**	**1.4**	**1.4**	**1.4**	**100.0%**
Gross electricity production [GwH]	**54,386**	**54,424**	**55,681**	**56,109**	**57,927**	**6.5%**
Self-consumption	2,007	1,602	1,398	1,276	708	
Net electricity production [GwH]	**52,379**	**52,822**	**54,283**	**54,833**	**57,219**	**9.2%**
Lignite	8,114	5,199	4,536	4,538	-	-100.0%
Petroleum (including refineries)	3,597	2,723	2,209	1,892	828	-77.0%
Natural Gas	22,963	21,894	19,169	16,229	18,304	-20.3%
Bioenergy	425	539	772	974	1,575	270.6%
Water plants (including mixed pumps)	5,453	6,410	6,528	6,581	6,596	21.0%
Wind plants	7,280	10,090	12,610	14,398	17,208	136.4%
Photovoltaic stations	4,548	5,967	8,202	9,712	11,816	159.8%
Solar thermal stations	-	-	257	258	260	
Geothermal stations	-	-	-	252	631	
Net electricity energy imports [GWh]	**6,200**	**5,165**	**4,946**	**4,752**	**4,578**	**-26.2%**

Total provision of electricity energy [GWh]	**58,579**	**57,987**	**59,229**	**59,585**	**61,797**	**5.5%**
Network / storage losses [GWh]	3,785	3,728	3,635	3,611	4,165	
Energy Sector Consumption [GWh]	1,158	1,093	1,164	1,169	1,201	
Final Electricity Energy Consumption [GWh]	**53,636**	**53,166**	**54,430**	**54,805**	**56,431**	**5.2%**
Share of RES in gross power generation	32.6%	42.3%	50.9%	57.3%	65.8%	33.2%
CO_2 emissions from electricity generation [Mt CO_2]	23	15	13	11	7	-69.6%

Source: NPEC (2019)

The development program of electricity infrastructure is expanding to include the interconnection of the Southern Cyclades, the Dodecanese, and the North Aegean through 2029 (Table 2-9).

Table 2-9 Assumptions of electricity infrastructure development program

Domestic Interconnections	Year of connection
Interconnection of Cyclades	
Phases A -C: Include the Electrical Systems of Syros, Paros (includes the islands of Naxos, Antiparos, Koufonisi, Schinoussa, Heraklion, Ios, Sikinos, Folegandros) and Mykonos (including Delos and Rhenia)	2018-2020
Phase D: Rest of the Cyclades (Western and Southern)	2023-2024: Interconnection 2025: Year of full operation
Interconnection of Crete	
Phase I: 150kV, 2x200 MVA	2020: Interconnection 2021: Year of full operation
Phase II: ESMIE takes over the entire energy load of Crete	2022: Interconnection 2023: Year of full operation
Interconnection of Dodecanese	2027: Interconnection 2028: Year of full operation
Interconnection of North Aegean	2028: Interconnection 2029: Year of full operation
International Interconnections	
2nd Interconnection with Bulgaria, 600 MW	2023

Source: NPEC (2019)

2.7.1 Climate energy targets

For climate change and emissions, NPEC seeks a 42%+ reduction of greenhouse gas emissions, compared to the emissions of 1990, and +56% compared to 2005, to exceed the EU targets. In the initial NPEC, these targets were significantly lower, a 33% and 49% reduction, respectively. The new GHG reduction targets will also enable the transition to a climate economy by 2050 and the participation of the Greek Government in a climate-neutral economy at the EU level (NPEC, 2019).

NPEC presents the initiatives of the National Strategy Adaptation to Climate Change (NSACC) that sets out the general objectives, guidelines, and tools for implementing climate adaptation measures at the national, regional, and local levels. Further, NPEC presents the initiatives of Spatial Planning Integration for urban areas in terms of sustainable land use and sustainable urban mobility. Respectively, Waste management is an integral part of national energy planning and climate. These initiatives are presented in the National and Regional Waste Management Plans, seeking to intensify effective measures for integrated waste management based on the requirements of the circular economy.

2.7.2 Renewable sources targets

For RES, NPEC seeks a significantly higher target than the share of gross final energy consumption of at least 35% and 32% of the European RES target. RES will also contribute to the energy transformation in the electricity generation sector as the share of RES in consumption is estimated at +60%. In this context, the Greek government promotes and implements specific initiatives, including the simplification and acceleration of the licensing framework, the optimal integration of RES in the electricity networks, the operation storage systems, and the promotion of e-mobility. Also, NPEC sets specific targets regarding the further utilization of RES to meet the thermal and refrigeration needs, especially in the building sector, and the promotion of dispersed production from RES and advanced biofuels in the transport sector (NPEC, 2019).

2.7.3 Energy efficiency targets

For improving energy efficiency, NPEC sets ambitious goals to exceed the corresponding European targets. In addition, a qualitative improvement is achieved in final energy consumption by 38%, compared to the EU targets of 32.5% and the original NPEC target of 32%. Achieving 38% in energy efficiency will strengthen the competitiveness of the Greek economy and consumer protection with an emphasis on the building sector and the transport sector (NPEC, 2019).

A key goal of the revised NPEC is de-lignification over the next decade and its complete disengagement from the domestic power generation system until 2028. NPEC presents the withdrawal schedule of lignite power plants to be completed by 2023. De-lignification addresses long-term environmental protection issues but also the rationalization of electricity generation costs. Further, it provides the adoption of integrated programs to support Greek lignite areas for the energy transition.

Table 2-10 Key policy priorities of the National Plan for Energy and Climate

Reduction of GHG emissions and environmental objectives	Increased participation of RES in energy consumption	Improving energy efficiency
Total emissions to be reduced at 40% compared to 1990 (actual reduction rate > 42%)	Share of RES in the gross final energy consumption to 35%	Achieve energy efficiency improvement by 38%
Achieve equivalent goals of emission reduction in individual sectors within and outside the Emissions Trading System, corresponding to EU goals	Share of RES in the gross final electricity consumption to amount to at least 60%	Final energy consumption not to exceed 16.5 Mtoe in 2030
Achieve quantitative targets to reduce national emissions of specific air pollutants	Share of RES in heating and cooling needs to exceed 40%	Primary energy consumption not to exceed the 21 Mtoe in 2030
Withdrawal of lignite units of power generation up to 2028	Share of RES in the transport sector to exceed 14% (actual rate 19%)	Achieve 7.3 Mtoe in cumulative energy savings during the period 2021-2030
		Annual energy renovation of 3% of the total area of the thermal zone of the buildings of central public administration by 2030

Source: NPEC (2019)

2.7.4 *Strategy in relation to the five dimensions of the Energy Union*

The European Energy and Environment Strategy promotes the abolition of energy borders between national energy markets and the strengthening of the EU energy security and independence. The main pillar of this Strategy is the completion of the internal energy market, which will be liberated and competitive and integrate the five dimensions of the European Union as explained in the following sections.

1. **Energy security**

Greece's geopolitical position as Europe's Energy Portal for new power sources from the Eastern Mediterranean and Central Asia and the growth potential of intra-Community power sources offer Greece a key role in Europe's energy transition in a climate-neutral economy by 2050. The provision and management of energy resources through the diversification of energy sources and flows to strengthen the security of supply in Greece and South-Eastern Europe shields the domestic market supply to protect consumers from supply disruption and emergency. Thus, the main strategic goal is to ensure the smooth, uninterrupted, and reliable coverage of domestic and regional energy needs and the access of all consumers (citizens, businesses, and public sector entities) to affordable and secure energy. In this way, the regional role of Greece in a region that lacks a mature energy market is strengthened.

2. **Sustainable energy market**

With the restructuring of its energy sector, Greece looks forward to the development and operation of competitive and economically viable energy markets that can offer competitive and transparent energy products and services to consumers. In addition, in a European and international climate-neutral environment, the transition to a lower-carbon energy system will enable new energy technologies to penetrate the energy market, providing opportunities for innovative investments and activities to enhance the competitiveness of the Greek economy.

3. **Low carbon economy**

Over the next decade, Greece will implement radical cuts in the electricity supply sector as the share of RES in electricity generation is sought to increase significantly and gradually replace the use of fossil fuels. The policies aim to achieve the integration of RES in the electricity market. Also, the projected reduction and eventual de-lignification for electricity generation highlight the issue of direct and indirect effects on growth and employment at the level of local communities in the lignite areas, thus creating requirements for the formulation of specific transition policies and their financing strategy.

4. Spatial planning

The continuous urbanization and enlargement of cities are challenges for spatial planning in Europe as the land consumption rate for urban uses exceeds the population growth rate. Hence, the primary goal of sustainability policy is to review the structure and operation of modern cities. The main issue arising is the promotion of urban models that correspond to urban areas in terms of distribution of functions, density, and hierarchy of their structure (center - local centers - a). The policies promoted concern changes in the shape, size, density of housing, planning, and location of activities in cities, which will result in differences in the pattern of energy demand and overall improvement of their energy and climate footprint.

5. Bioclimatic and urban planning

The geometry and location of buildings, urban streets, and public outdoor space, the use of unsuitable materials on surfaces, the lack of greenery, human activities, and land uses, determine the energy behavior of an urban area and the urban heat island phenomenon. Hence, the rise in temperature within urban areas during the day and night and the increase in energy consumption relates to bioclimatic and urban planning. A policy goal is a bioclimatic design (urban and architectural) to harmonize building sizes, roads, public space, and urban areas with the environment and the local climate to get immediate results in energy savings while improving the urban environment and the quality of life.

Table 2-11 presents a comparison between the results of the original NPEC in 2019, and the final NPEC which incorporates the latest policy commitments. The new differentiated goals lead to new estimates about the evolution of the energy system, with different results in terms of the structure and participation of fuels and technologies. The revised objectives of the final NPEC for 2030 are characterized by higher penetration shares of RES in gross and final energy consumption, greater improvement of energy efficiency, lower final energy consumption, and de-lignification.

Table 2-11 Revised national objectives under the NPEC

Target year: 2030	Final NPEC	Original NPEC	New goals based on EU goals
Share of RES in Gross Final Energy Consumption	≥ 35%	31%	Increased ambition in relation to EU goal of 32%
Share of RES in the gross final electricity consumption to amount to at least 60%	61-64%	56%	-
Final energy consumption	16,1-16,5 Mtoe (≥38% compared to 2007 forecasts)	18.1 Mtoe (32%) (referred to 17.3 Mtoe without considering the heat of the environment)	Increased ambition compared to the EU goal of 32.5% and goal achievement compared to 2017
Share of lignite in energy production	0%	16,5%	
Greenhouse gases	≥42% compared to 1990, 656% compared to 2005	33% compared to 1990, 49% compared to 2005	In compliance with the EU objectives and overperformance in relation to national commitments to sectors outside Emissions Trading System

Source: NPEC (2019)

2.7.5 Challenges

The most important challenge for most policy measures is to effectively address the complexity of the various components (technical, managerial, administrative, institutional, social). For example, the lack of necessary infrastructure to promote gas in the transport sector or the efficient management of waste streams are both major obstacles.

Improving energy efficiency is the biggest challenge for public policies to be implemented over the next decade. Achieving energy savings by improving energy efficiency leads to multiple benefits such as reducing greenhouse gas emissions, reducing energy costs, improving the comfort conditions in buildings and public areas, increasing added value and employment, and improving the competitiveness of businesses.

The reduction of fluorinated gas emissions requires the intensification and coordination of the existing control and enforcement mechanisms. Also, when policy measures are related to the agricultural sector, the main challenge is the integration of small and medium-sized enterprises in the project.

Finally, the lack of control and certification procedures is an obstacle to the proper implementation of policy measures. In addition, in some cases, there is a lack of a regulatory framework to facilitate the implementation of policy measures and achieve the objectives of NPEC.

2.8 Chapter conclusions

The energy transformation of the Greek energy system relates to the Global Sustainable Development Goals (SDGs). The goals for sustainable development require the transition to new production standards and the need for sustainable cities. Further goals include the eradication of poverty, the creation of flexible infrastructure, the promotion of sustainable industrialization, the circular economy, and the promotion of innovation. The implementation of the measures of the new Greek Energy Policy and the achievement of energy and environmental objectives requires the radical transformation of the Greek energy system over the next decade and, therefore, the implementation of investments in capacity utilization for domestic energy production, energy networks, interconnections, and energy infrastructure.

3. Different sectors analysis

3.1 Introduction

In recent years, a great effort is made towards the use of alternative sources of energy as oil reserves are not inexhaustible, and the greenhouse effect on the environment is becoming more intense. However, the importance of oil remains strong. Energy consumption, especially in strongly developing countries, is constantly increasing, largely offsetting alternative energy sources. Further, certified hydrocarbon reserves are still relatively large, while the capital invested in the oil sector is high.

Many human activities require the burning of fossil fuels, which increase the release of CO_2 in the atmosphere and result in raising the global average temperature and climate change. Globally, the energy demand is growing, thus reinforcing the tendency to increase CO_2 emissions. Most countries rely on fossil fuels (oil, gas, and coal) to meet energy demand. Combustion of these fuels releases heat that can be converted into energy. In this process, the carbon in the fuel reacts with the oxygen, producing CO_2, which is released into the atmosphere. Air pollutants, sulfur dioxide, nitrogen dioxide, etc., are also released, with consequent effects on air quality. However, thanks to technical measures and improvements in power plants and heat plants, these emissions have been reduced in recent decades.

The average European uses 27 megawatts per hour (MWh) per year, including all domestic, industrial, and transport sources. This magnitude varies considerably from country to country, and the same applies to the relevant CO_2 emissions, which are directly dependent on the penetration of renewable and nuclear energy (EEA, 2021).

The following sections present and analyse different sectors of energy and their contribution to the Greek energy system.

3.2 Oil industry companies

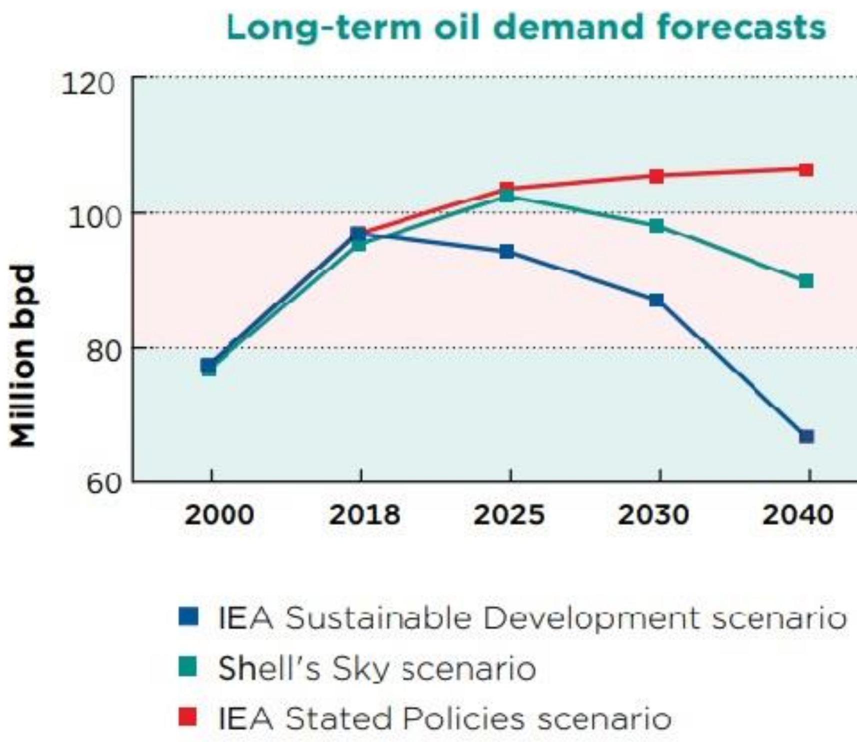
Many political and environmental leaders around the globe are cautious of the future role of oil and gas companies and advocates of the complete elimination of fossil fuels from the energy system. The oil and gas industry faces increasing pressure from governments, investors, and the public towards the decarbonization of the energy system. In turn, financial markets have soured on the sector due to investor uncertainty about the future growth of oil and gas; the energy sector of the S&P 500 index has plummeted by 48% since 2015, thereby becoming the worst performing sector in the index during that period (Krauskopf, 2019).

Sustainable growth in global energy demand and its ability to outperform the use of alternative sources of energy is challenging for oil-producing companies. Oil companies must respond to several mandates towards a low-carbon energy system while still satisfying long-term global demand. In this context, oil companies (Johnston, 2020):

- Diversify business models to put emphasis on coal-to-gas switching or lower GHG intensity as a complement to RES.
- Support the growth of decarbonization technologies for oil and gas (e.g., methane efficiency; zero-emissions production; hydrogen).
- Assess geopolitics to diminish exposure to “stranded assets,” such as long cycle oil projects in high cost or high political risk areas while recognizing projects or partnerships in areas with higher long-term oil demand.
- Integrate Environment Social Governance (ESG) principles into business models and communicate energy transition and future oil and gas demand to stakeholders.

Sustainable Development Scenario suggests global oil demand at 66.7 million barrels per day in 2040, 30% below 2018. The shift is supported by significant growth in electric vehicles, energy efficiency, biofuels, and hydrogen. The forecast for gas demand is at the 2018 levels in 2040, at 3,854 billion cubic meters (bcm) per year. Shell Sky Scenario that considers economy-wide net-zero emissions through 2070 estimates oil demand at 4% and natural gas demand at 8% through 2050 (Figure 3-1).

Figure 3-1 Long-term oil demand forecasts



Source: Johnston (2020)

3.3 Natural Gas & LNG

There is an ongoing struggle by the governments around the world to provide better transport routes for natural gas and LNG and capitalize on the growing interest in these compounds by offering their pipeline territory. In the early 2000s, Greece participated in the changing energy landscape with the Burgas-Alexandroupolis pipeline and the South Stream Pipeline. The Burgas-Alexandroupolis pipeline was signed on March 15, 2007, between Russia, Bulgaria, and Greece and set out the establishment of an International Company to undertake the construction and management for transporting crude oil from the Caspian Sea to the port of Alexandroupolis. Yet, in 2010, Bulgaria announced its withdrawal from the implementation plan citing economic and environmental reasons. As a result, the project was cancelled. Likewise, the South Stream

Pipeline was an agreement for the transportation of gas from Russia to the European Union countries bypassing Ukraine. Specifically, it would cross the Black Sea to Bulgaria, then branching into the Austria route and Italy through Northern Greece, the Ionian, and the Adriatic. The Greek section of the pipeline was scheduled to transport Russian gas to Greece and Italy at the end of 2015. Yet, the project was cancelled as well.

In January 2020, Greece signed the Eastmed pipeline with Cyprus and Israel to connect the natural gas fields of the Eastern Mediterranean with the European market through Cyprus and Greece. The cost of the Eastmed project exceeds €5.2 billion, its length is 1,900 km, and the pipeline capacity is 10 billion cubic meters per year, with the possibility of doubling in the future (Koutantou, 2020).

Today, Greece is supplied with natural gas from the following four points of entry: Agia Triada (LNG via the Revythousa terminal), Kipoi (Greek-Turkish interconnector), Nea Mesimvria (TAP pipeline) and Sidirokastro (Gaziko aro). Following the abolition of the Trans Balkan Pipeline by Gazprom, which transported Russian gas via Ukraine, Romania and Bulgaria, the quantities we now receive (from 1/1/2020) from Gazprom pass through Turkey, after being transported via the Turk Stream pipeline which transports Russian gas through the Black Sea and then by land to the European part of Turkey and from there to Bulgaria.

More specifically, in January, from 6.9 TWh, 37.0% were imported through the gate of the Holy Trinity and came from LNG gasification, 2.7 TWh, 40% were imported through Sidirokastro (on the Greek-Bulgarian border), 0, 4 TWh or 6.0% were imported through Gardens (see Turkish Basket) while 1.2 TWh or 17.0% were imported via New Midday, originating in Azerbaijan via the TAP pipeline (Stambolis, 2021).

Regarding the use of natural gas in road transport, liquefied natural gas will be used as a fuel for heavy vehicles. In this context, NPEC plans to develop a network of 8 supply stations of LNG until 2030. Also, the network for refuelling compressed natural gas is under development, and by 2030, will operate 55 compressed gas supply stations throughout Greece to meet the relevant demand (NEPC, 2019).

In April 2021, the Government of Northern Macedonia reviewed and approved the text of the harmonized agreement for the construction of the interconnected natural gas transmission pipeline between Greece and Northern Macedonia. The interconnection pipeline will start from Nea Mesimvria in Thessaloniki, Greece, and will end in Stip, Northern Macedonia (HAEE. 2021).

Further, the merger with Bulgaria took place on May 11, 2021, for the creation of a Single Day-ahead Coupling (SDAC) that will release a single pan European cross zonal day-ahead electricity market. An integrated day-ahead market will improve the efficiency of trading by fostering fair competition, boosting liquidity, and facilitating a more efficient utilisation of the generation resources across Europe (Entsoe, 2021).

3.4 Coal industry

The global coal industry will never recover from the COVID-19 pandemic, industry experts predict, because the crisis has shown that renewable energy is cheaper for consumers and a safer haven for investors. A long-term move away from fossil fuels has accelerated during the shutdown, pushing the closure of power plants in many countries. As electricity demand has declined, many utilities have reduced coal use because it is more expensive than gas, wind, and solar energy. In the EU, coal imports for thermal power plants have fallen by two-thirds in recent months to levels not seen in 30 years (Energy Press, 2020).

Egenhofer et al. (2020) claim that the economic slowdown caused by the pandemic will worsen the existing pressure in some regions, especially those dependent on lignite and coal. For carbon-dependent regions, the European Commission needs a topocentric regional approach that capitalizes on the benefits of the European Green Agreement while identifying urgent actions. Member States need to strengthen their regional strategies for coal regions in the light of the recovery measures and the European Green Agreement on the forthcoming multiannual financial framework 2021-27, considering the transition to a more sustainable economic structure with lower carbon emissions. Also, proper EU mechanisms should be used to restructure energy production with low carbon emissions, using existing know-how and infrastructure.

In the Brussels Summit (September 14-17, 2020), the European Parliament voted to reduce carbon dioxide emissions from the shipping industry and undertake more ambitious action in the European CO2 system in the maritime transport sector. Members of the European Parliament largely agreed that the reporting obligations of the EU and the International Maritime Organization need to be aligned, as the Commission points out in a proposal to review the European system for monitoring, reporting, and verifying carbon dioxide emissions from maritime transport (EU-MRV Regulation). Notably, the shipping sector remains the only sector without specific European commitments to reduce greenhouse gas emissions. Global shipping activity emits a significant amount of greenhouse gases, accounting for 2-3% of total world emissions. In 2017, 13% of total EU greenhouse gas emissions came from the maritime transport sector (European Parliament, 2020).

At the beginning of 2021, countries that account for more than 65% of global carbon dioxide emissions and more than 70% of the world economy have ambitious commitments for a carbon-neutral balance. With the full implementation of the Green Agreement and the inclusion of climate change in the long-term budget, the European Union can show the world that it can move towards climate neutrality and climate resilience (United Nations, 2021).

3.5 Power plants

The Greek energy sector depends heavily on fossil fuels and petroleum products. In 2019, the total installed capacity was 21.1 GW, including 11 GW of thermal plans and 10.1GW of RES plants. Between 2021 and 2030, most of the RES plants will be interconnected with the continental electricity system, leading to a further reduction of oil imports for electricity generation. The operation of autonomous electrical systems in the Greek islands will be based on oil power plants, as seen in the achievement of interconnection between Paros, Syros, and Mykonos in the Cyclades (Energypedia, 2021). In addition, the completion of the electricity interconnection between Crete and Peloponnese in May 2021 is the first step in lifting the energy blockade and the transition of Crete to a cleaner energy mix. The project will cover 1/3 of Crete's energy needs, replacing the production of the older local units, which are expensive, followed by the interconnection between Heraklion and the Attica region, which is under construction (Naftemporiki, 2021).

As of December 2019, 6,965 MW of RES and high efficiency cogeneration power plants operate in Greece. These include 3,607 MW of wind power plants, 2,793 MW of photovoltaic power plants, 240 MW of small hydropower, 88 MW of biomass/biogas plants, and 233 MW of high efficiency cogeneration power plants (Energypedia, 2021).

Over the next decade, RES will play a leading role in the domestic energy mix. Especially in the field of domestic electricity generation are expected to have a share of over 50% through 2025. While in the previous years, a support regime for providing operational support was required, technology advancements have matured. Thereby, the cost of generating electricity from RES has become largely competitive. The promotion of RES technologies for electricity generation with the least possible operational reinforcement is critical over the following years, as these technologies will gradually reduce the charges imposed on consumers for the development and operation of RES stations. Specifically, the cost for photovoltaic and wind plants will further decline until being eliminated in the medium term because RES technologies will be fully competitive in terms of the electricity market and will not require financial aid for their operation. Also, RES stations will operate within the framework of bilateral or forward contracts between producers and suppliers, consumers, and representation bodies to hedge risk from the increased consumer prices and offer investor and producer protection (NPEC, 2019).

Law 4414/2016 provided a new support scheme for renewable electricity in Greece, stipulating that all new power stations must participate in the electricity market by submitting a priced offer-forecast, either directly or through renewable energy aggregators. Also, revenues based on the cost of market-based operating aid must guarantee that the projects are neither overcompensated nor under-compensated (Norton Rose Fulbright, 2016).

According to National Plan for Energy and Climate, RES units will share fully distributed power generation characteristics (i.e., stations to exploit geothermal fields, biomass, and biogas) and are expected to quadruple their current installed capacity through 2030. RES units will ensure the proper operation of the domestic electrical system considering the large quantities of electricity generation from uncontrolled RES and will act as balancing factors. On the other hand, RES power plants pose a challenge regarding the development of the energy system because they require optimal coordination, both in the licensing and construction phase and in the operation phase (NPEC, 2019).

3.6 LNG processing plants

The largest floating LNG processing unit in the world belongs to Royal Dutch Shell. Oil and energy giant has built the world's largest floating gas treatment and liquefaction plant (FLNG Facility), “Prelude”, with a displacement of 600,000 tons, length 488 m, width 74.5 m, and height 105 m. "Prelude" has a capacity of 300,000 GT, was built by Samsung Heavy Industries, and cost more than $10 billion. “Prelude” will stay on the coast of West Australia, at least for the next 20 years, exploiting the underwater deposits located in the area. The project is important for Shell as it will provide LNG to the company's customers around the world. Further, it will contribute to strengthening Shell's position and performance in the natural gas sector worldwide (Naftika Chronika. 2017).

The Greek market is transformed into a decentralized market with optional participation of market players in a Power Exchange to comply with the Single European Market Model (Target Model). In addition, the free conclusion of bilateral contracts between producers and suppliers for the sale of electricity is key to the new target model. Demand forecast for the period 2020 - 2029 considers the distribution of demand for electricity generation and the distribution of demand among Other Consumers. The study prepared by the Aristotle University of Thessaloniki (AUTH) considers the annual forecast of demand and geographical-daily distribution of other consumers as prepared by DESFA (2019). The AUTH study simulated the Greek wholesale energy by estimating:

(1) the annual growth rate of energy demand,

(2) expected or not environmental upgrade of lignite plants,

(3) construction or not of new plants,

(4) expected time of interconnection of mainland Greece with Crete, and

(5) fluctuations in crude prices and CO_2 allowance prices.

Based on the above assumptions, the following scenarios are developed:

Scenario 1 (low scenario for VAT consumption)

a) Low-demand scenario.
b) Oil (Brent) Price will drop from $72 / barrel in May 2019 to $70/barrel in December 2029.
c) The price of CO_2 will reach €30.11/T in December 2029.
d) An additional gas unit (443 MW) will be built in Crete, commercially available in July 2024.

Scenario 2 (intermediate scenario for the consumption of VAT)

a) Intermediate demand scenario
b) Oil (Brent) Price will drop from $72 / barrel in May 2019 to $ 59.6/barrel in December 2029 (under ICE futures contracts),
c) The price of CO_2 will reach € 30.11/T in December 2029.
d) An additional gas unit (443 MW) will be built in Crete, commercially available in July 2024.

Scenario 3 (high scenario for VAT consumption)

a) High demand scenario.
b) Oil (Brent) Price will drop from $72/barrel in May 2019 to $59.6/barrel in December 2029 (under ICE futures contracts).
c) The price of CO_2 will reach € 35.11/Ton in December 2029.
d) A new gas unit with an installed capacity of 660 MW will start operating in January 2024.

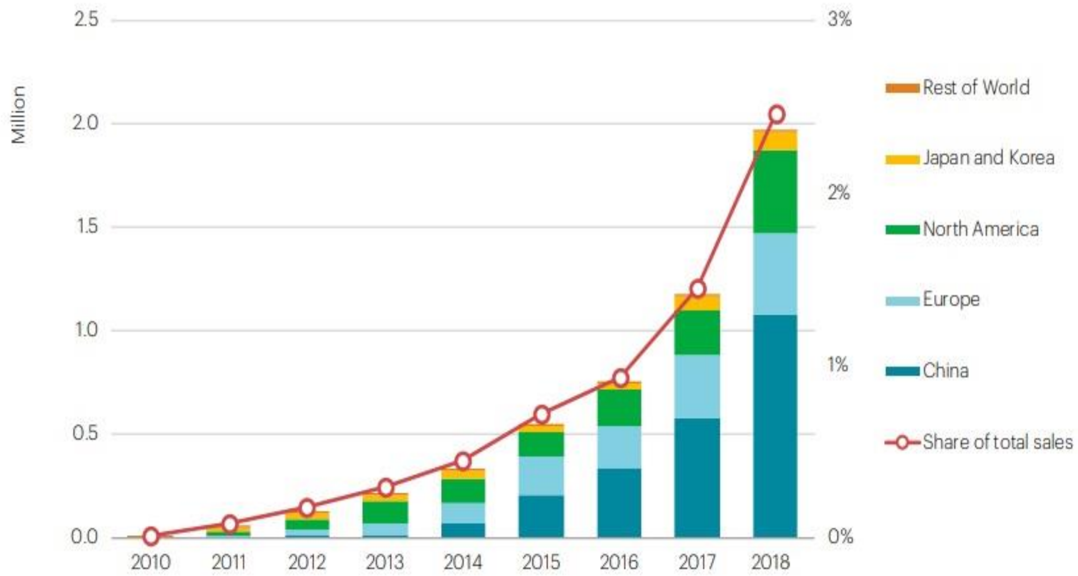
3.7 Energy constructions, electromobility, energy buildings

Research and innovation activities related to improving the energy efficiency of buildings will include (NPEC, 2019):

- Innovative building materials and technologies that can support recycling. Innovative thermal insulation building systems with improved thermal performance. Innovative pre-insulation materials from mineral sources. Prefabricated active elements for facades and roofs, such as panels for ventilated facades or ceilings that combine photovoltaic and thermal solar systems, thermal insulation, and more.
- Cost-effective flexible heat pumps and heat pumps for high temperatures including smart heat pump adjustable to provide additional services to the network; flexible AC to provide greater operating range and operation control equipment, further development & availability of absorption technologies and AC systems gas adsorption.
- Digital programming and optimization of operation, automated detection and error diagnosis, a combination of statistical and technical data to improve energy demand forecasts, and update/upgrade of building evaluation methods. The industrial sector will support energy-efficient heating and cooling technologies, heat pumps with low global warming potential refrigerants for use in industrial medium temperature applications, and district heating-cooling.
- Heat / Cold Recovery will be achieved with low-temperature waste heat to generate electricity at higher efficiencies, high-temperature waste heat recovery with sCO2 cycle, and hybrid stations for waste heat upgrade that incorporates RES installation.
- Systems integration: Industrial coexistence of energy-intensive industries to harness energy loss streams and better global energy management, non-conventional energy sources in the manufacturing industry, and further integration of digitization in process and plant management.

E-mobility car sales reached 2 million vehicles in 2018, a +70% y-o-y increase and the highest growth since 2013. China is the leading electric car market, with more than 1.1 million electric cars in 2018, 55.0% of total sales. China is followed by Europe, with 385,000 electric vehicles (19.3%) and the United States 360,000 electric cars (18.0%). As expected, passenger vehicle sales in China declined (IEA, 2019). Norway is the leading country in electric vehicle sales penetration, approaching 50%, followed by Iceland with 20%. Norway is also the leader in sales volumes, followed by Germany, the United Kingdom, and France. In the United States, the launch of the Tesla Model 3 drove market growth, whereas Japan experienced decreased sales. Globally, electric vehicles sold in 2018 are expected to offset 0.1 million barrels per day (mb/d) of transport oil demand growth. Also, electricity demand is estimated at approximately 12TWh per year, 1% of global power demand growth in 2018 (Figure 3-2).

Figure 3-2 Global electric cars sales, 2018



Source: IEA (2019)

Energy buildings are buildings with almost zero energy consumption and high energy efficiency as the energy required to meet their energy needs is largely covered by renewable energy sources. Nearly zero energy (nZEB) buildings have components of high energy standards, electromechanological (E/M) installations of high-energy efficiency, and a significant share of energy consumption covered by renewable energy sources locally.

Each EU Member State must CRES, 2021):

- Determine the specifications of the energy requirements for the shell elements of the buildings and the percentage of coverage of energy needs from RES.
- Determine the technical characteristics of its buildings with almost zero energy consumption, considering national, regional, or local conditions, including a numerical indicator of primary energy use in kilowatt-hours per square meter per year (kWh / m2yr).
- Prepare the intermediate goals for the improvement of the energy efficiency of the new buildings.
- Provide information on policies and economic or other measures taken to promote buildings with almost zero energy consumption, including details of national requirements and measures for the use of renewable energy in new buildings and existing buildings undergoing a radical renovation.

The methodology for calculating the energy efficiency of nZEB buildings should be harmonized in the Member States, have process quality control mechanisms and penalties in cases of non-enforcement. The calculation methodology shall be determined considering at least the following (CRES, 2021):

- the actual thermal characteristics of the building (including its internal partitions) - heat capacity, thermal insulation, thermal bridges,
- the installation of heating and hot water supply, including the characteristics of their thermal insulation,
- the installation of air conditioning, including the characteristics of its thermal insulation,
- natural and mechanical ventilation, which may include airtightness,
- the installation of general lighting,
- the design, location, and orientation of the building, including external climatic conditions,

- passive and hybrid solar systems and solar protection,
- passive heating and cooling,
- indoor climatic conditions, considering indoor climate design conditions, and
- the internal loads

In addition, each EU Member State should calculate the optimal cost levels of the minimum energy efficiency requirements for new and existing buildings and structures. In the methodological framework each EU Member State should specify the rules for comparing energy efficiency measures, measures for incorporating renewable energy sources, packages, and variants of these measures, based on the efficiency of primary energy and the cost of their implementation, and how these rules are applied to selected reference buildings to determine the optimal cost levels of the minimum energy efficiency requirements (CRES, 2021).

3.8 Chapter conclusions

The continuing rapid decline in weighted electricity costs for commercially more mature and competitive RES technologies, namely photovoltaic and wind projects, is expected to continue and intensify in the coming years. The extended application of competitive submission procedures for these projects will accelerate the achievement of full competitiveness of their operation in terms of the electricity market, thereby being developed without any operational reinforcement. These stations will be directly involved in the electricity market energy with the same obligations as the other participants. Hence, the development of appropriate mechanisms is key to ensure market participation in the most economical way for the entire energy system.

4. E-mobility in Greece

4.1 Introduction

The Law 4710/2020[19] on the promotion of e-mobility in Greece paves the way to developing a new form of mobility that will drastically reduce average CO2 emissions, improve the quality of air and life of citizens, and gradually renew the aging fleet of vehicles. The new law also gives significant incentives for purchasing BEV or PHEV, scooters, and bicycles as it offers environmental tax enforcement, tax incentives, and grants and provides for parking spaces for e-vehicles, spatial planning regulations, and urban planning regulations.

4.2 E-mobility in Greece

Cities are at the heart of the transition to sustainable mobility. Sustainable urban planning moves towards the creation of compact cities and the reduction of urban sprawl. According to Lardier (2020), a compact city promotes the intensive use of space with grouped housing and urban clusters. Housing clusters are closely positioned and have clearly defined boundaries. Most services are offered in an outlined area, easily accessible by foot or bicycle, whereas these cities also have a well-functioning public transportation system. In this context, cities address mobility and infrastructure demands for better mobility to limit the traffic and pollution caused by driving. However, such innovations are adopted by cities and eco-districts that support electric carsharing services, such as Amsterdam, Madrid, Paris, and others.

The low-emission mobility strategy, published by the European Commission in 2016, seeks to implement measures to enhance the sustainability of the transport system. These actions aim at reducing greenhouse gas emissions and launching

[19] https://www.taxheaven.gr/law/4710/2020 (in Greek)

investments in clean transport. Specifically, the goals of the low-emission mobility strategy are (European Commission, 2016):

- To increase the efficiency of the transport system by capitalizing on digital technologies and lower emission transport modes.
- To accelerate the implementation of low-emission alternative energy for transport, using biofuels, hydrogen, and renewable synthetic fuels and abolishing the barriers of transport electrification.
- To move towards zero-emission vehicles.

Between 2015 and 2020, 426 battery electric vehicles (BEV) and 715 plug-in hybrid electric vehicles (PHEV) were sold in Greece (Table 4-1).

Table 4-1 Sale of BEV and PHEV cars in Greece (2015-2020)

	2015	2016	2017	2018	2019	Total 5-years
BEV	54	41	53	88	190	**426**
PHEV	21	55	138	211	290	**715**
Σύνολα	**75**	**96**	**191**	**299**	**480**	**1141**

Source: Galanopoulos (2021)

In June 2020, the Greek government announced extensive subsidies to boost e-mobility in the country and achieve every third vehicle to be electric by 2030. In the first phase, Greece has a budget of 100 million euros to purchase insurance premiums for a period of 18 months (Randall, 2020). The subsidy rate in the original bill amounted to 15% and up to 5,500 euros. In July 2020, the Minister of Environment and Energy increased the subsidy rate to 20% or up to 6,000 euros for vehicles with a retail value before tax up to 30,000 euros. For electric vehicles with higher retail values before tax, the subsidy rate is reduced to 15% and up to 6,000 euros (Andris, 2020). Apart from the tax breaks, electric cars will become cheaper up to 10,000 euros and will not be subject to parking fees for two years, and electric motorcycles are subsidized. Finally, every new building should have the infrastructure to charge electric vehicles, and subsidies for professional drivers (e.g., taxi owners and corporate vehicle fleets) who move to big cities will be higher (Randall, 2020).

The factors affecting the sale of electric vehicles typically include the availability of models, local promotions, shared car rental services, and the average annual income. Also, electric vehicle markets tend to grow in parallel with the local charging infrastructure. Greece is still lagging compared to other European and global markets mainly due to the lack of infrastructure for charging the car battery. For example, WFW (2020) claims that in 2019, there were about 115 public charging points in Greece, of which only ten had fast chargers, while the current need is for at least 3000 charging points. On the other hand, several political and private organizations (e.g., Hellenic Institute of Electronic Vehicles) have introduced initiatives to render Greece more e-mobility friendly through the provision of incentives that can increase EV penetration in the Greek market.

In 2021, Greece ranked in 17th place among 21 countries in the EV Readiness Index 2021 with a total score of 16. The highest score (12) is seen in the total costs of ownership, while the score in e-vehicle maturity is 3 and in charging maturity is 1. Yet, Greece improves its position by 2 places compared to 2020 (Figure 4-1).

Figure 4-1 Greece ranking in the EV Readiness Index 2021

#	Country	Total score	1. E-vehicle maturity	1. Charging maturity	3. Total cost of ownership	Position last year
17	Greece	16	3	1	12	↑ 19

Source: Lease Plan (2021)

Currently, the register of the Ministry of Infrastructure and Transport includes 2,000 purely electric vehicles, of which 1,130 were incorporated and registered in 2020. The Ministry of Infrastructure and Transport works in three axes (4 Troxoi, 2021):

a) Licensing of specialized workshops and special license for electric vehicle technicians. Consultations are already underway to update the charger specifications for an adequate charging network.

b) Creating a register of operators to provide data (e.g., the driver will be informed about charging points, costs even if there is a queue to charge etc.).

c) Funding.

4.3 Chapter conclusions

Urban areas in Greece need to be driven by digitization, automation, and other innovative solutions. A key area for the transition to a clean, resource-efficient, and carbon-neutral future is mobility, including urban mobility, trans-European networks, road transport, shipping, and air transport.

Greece should give priority to clean and affordable alternatives and develop charging maturity, aiming to have zero-emission vehicles and to use digital technology to reduce fuel consumption. In terms of urban mobility, the change of the conventional traffic design until today is promoted, prioritizing comfortable movement of private cars and the design of sustainable human-centered urban mobility.

5. Investments and Brands

5.1 Introduction

Strong interest from all major players in the Greek gas market was recorded during the annual auction conducted by DESFA for the reservation of time slots for the import of liquefied natural gas LNG cargo at the Revythousa terminal in 2021. As officially announced by the administrator, the LNG Terminal was granted 35 slots out of a total of 46 available during the first phase of the auction. The total amount of liquefied natural gas loads to be imported is 4,357,445 cubic meters. The distribution according to DESFA was made in seven companies: PPC, DEPA, Elpedison, IRON, Motor Oil, Mytilineos, and Prometheus. Now the market has reached equilibrium and the prices of LNG are largely close to the levels of the prices of gas imported through pipelines. This is helped by the recovery of brent prices, which affects the gas pricing formulas of the pipelines.

An additional reason for the significant demand recorded for imports of LNG loads is the new conditions in the electricity market and the need for generators to have natural gas available to take advantage of the opportunities in the balancing market of the Target Model (Floudopoulos, 2020). This explains DEPA's Poseidon Med program that establishes LNG as an eastern Mediterranean marine fuel. Phases I and II of the program were completed in June 2020. POSEIDON MED II is a European program for designing the legal framework and conditions for the use of LNG as a maritime fuel in the Eastern Mediterranean. Through the design of targeted and sustainable infrastructure, the program contributes to the development of the LNG supply chain and activates the LNG demand for maritime use to meet modern international environmental requirements (DEPA, 2020).

The actions of the POSEIDON MED program include (DEPA, 2020):

- Preparation of regulatory framework proposals for the refueling of ships with LNG as a marine fuel.

- Plan to upgrade the infrastructure of the LNG Terminal of Revythousa that will ensure the possibility of loading LNG on refueling vessels.
- Technical design approved by the competent authorities for the conversion/construction of ships with LNG fuel as well as for the creation of the necessary port infrastructure to support the supply of LNG ships.
- Design and construction of a special container transport ship that will run with LNG (pilot action in the region of Venice - Italian participation).
- Examining synergies with other uses and sectors (such as energy) that will generate economies of scale in the use of LNG.
- Development of a sustainable LNG pricing/marketing scheme.
- Development of financial tools to support port and ship facilities.

The duration of the program was from 01/06/2015 to 31/12/2020 with the participation of Greece, Italy, and Cyprus. The studied ports were Piraeus, Patras, Heraklion, Igoumenitsa, and Limassol. The cost of the project was €53,279,405, financed by 50% from the participating countries and by 50% from the European Commission. The program coordinator was DEPA, and the technical coordinator was DESFA.

On the other hand, the significant increase recorded in the cost of connection conditions for photovoltaics by HEDNO poses difficulties for small investors. About 70% of small producers receive an offer of connection terms over 50,000 euros, while in about 40% of these cases the cost exceeds 65,000 euros (HAEE, 2021).

This chapter presents energy investments from Greek companies.

5.2 Energy investments from Greek companies

5.2.1 Mytilineos

Mytilineos is making a big leap in the field of Renewable Energy Sources. RES are the forerunner of the company's large exit in the markets for the issuance of a new bond, acquiring a portfolio of photovoltaic projects with a total capacity of

1.48 GW belonging to the Egnatia Group. Mytilineos is becoming one of the largest producers of green energy, covering 50% of the target for 3 GW from RES by 2030.

The green deal of Mytilineos that dynamically expands to clean forms of energy includes the acquisition of 21 photovoltaic parks. These are projects that will be developed in the context of strategic investments and belong to the latest round of approvals that were recently authorised by the ministerial committee for 56 million euros. The market anticipates that this is a project that will be financed by the new bond planned by Mytilineos and will be close to 900 million euros. In the context of the adoption of policies that will facilitate the energy transition, Mytilineos announced that has agreed to contract a PPA with the electricity market for photovoltaic parks owned by the Egnatia Group, with a capacity of 200 MW for 33 euros Mwh for a period of 10 plus 5 years. The PPA is estimated to enter into force in 2023. Furthermore, the company announced that has projects of 1,480 MW in the mature licensing phase, 300 MW in the operation and construction phase or ready for construction, and 100 MW in the final investment decision (Tzanne, 2021).

5.2.2 Landis + Gyr

Landis + Gyr's new investment in Greece is being completed and is larger than planned. According to the Vice President and CEO of the Greek subsidiary Aristidis Pappas, the investment reached 10 million euros. The project moved faster and is expanded in size as the entire production is transferred to Greece. The new factory in Corinth is ready, and new production lines have been installed and put into operation. Also, Ladis + Gyr group will participate in the PPC tender for the replacement of 7.5 million analog clocks with smart meters that HEDNO is expected to proceed with during 2021.

The Swiss multinational group for the production and marketing of electrical and electronic equipment and energy management systems has been providing a vote of confidence in Greece in recent years. In 2016, Ladis + Gyr transferred the production lines of industrial cash from Switzerland and in 2017 transferred a large mass of household cash from Great Britain. From 2016 onwards Landis

+ Gyr has invested over 35 million euros in Greece. Further, the domestic subsidiary is extroverted as it exports over 90% of its production to dozens of countries around the world, while a large part of its exports is directed to the US market (Grimanis, 2021).

5.2.3 Other projects

The implementation of new gas units is accelerated. Both PPC and private groups are moving at an faster pace for the construction of new gas power plants. In March 2021, PPC obtained a production license from RAE for a 665-megawatt power plant in Komotini, while Elpedison entered a tender for its own power plant in Thessaloniki with a capacity of 826 megawatts. Similar projects have been launched by GEK TERNA for a 665MW unit in Komotini, ELVAL HALCOR for a 566MW unit in Thisvi, the Kopelouzos group for a 662MW unit in the Alexandroupolis industrial area, and the Karatzis group in Larissa. Also, the Mytilineos unit in Agios Nikolaos, Boeotia is expected to be put into operation at the end of 2021 with a capacity of 826MW (HAEE, 2021.)

5.3 Chapter conclusions

As the main sources of greenhouse gas emissions come from the energy sector, global organizations such as the UN, governments, businesses, and local communities are turning to Renewable Energy Sources (RES). The Greek government has decided to pursue a consistent innovation strategy by promoting projects and investments in key policy areas, which are at the heart of European policy for the future: climate protection, renewable energy development, education and training, and the transition of the economy and public administration to the digital age.

6. The impact of energy investments on the economy

6.1 Introduction

The growing institutional requirements to reduce the environmental impact of the electricity sector and the cost of electricity generation from renewable sources have catalytically contributed to the development of new technologies that claim a large share of investment funds.

In Greece, the requirements for achieving the desired long-term economic growth are complex, emanating from the economic, political, and institutional context that poses important restrictions. These restrictions address the need for the gradual convergence of the economy in terms of structure, productivity, and competitiveness at a level that will not be significantly lower than the EU average. In this context, prioritising the exploitation of comparative advantages that can support economic growth is critical (Vettas, 2016).

This chapter attempts to approach the economic and social impact of energy infrastructure on a global and national level by presenting existing studies and methodology for calculating economic and social factors that affect the development prospects of specific energy forms globally and domestically.

6.2 The use of RES technologies and economic growth

The adverse environmental effects of typical energy forms of production and usage and the limited yields of conventional sources of energy have created the necessity for renewable energy sources (RES). Governments around the globe are required to develop adequate policies to promote the use of RES. Today, about 19.0% of total energy usage is RES-generated, while the strategic goal is to increase their usage by 50% by 2050 (Svenfelt et al., 2011).

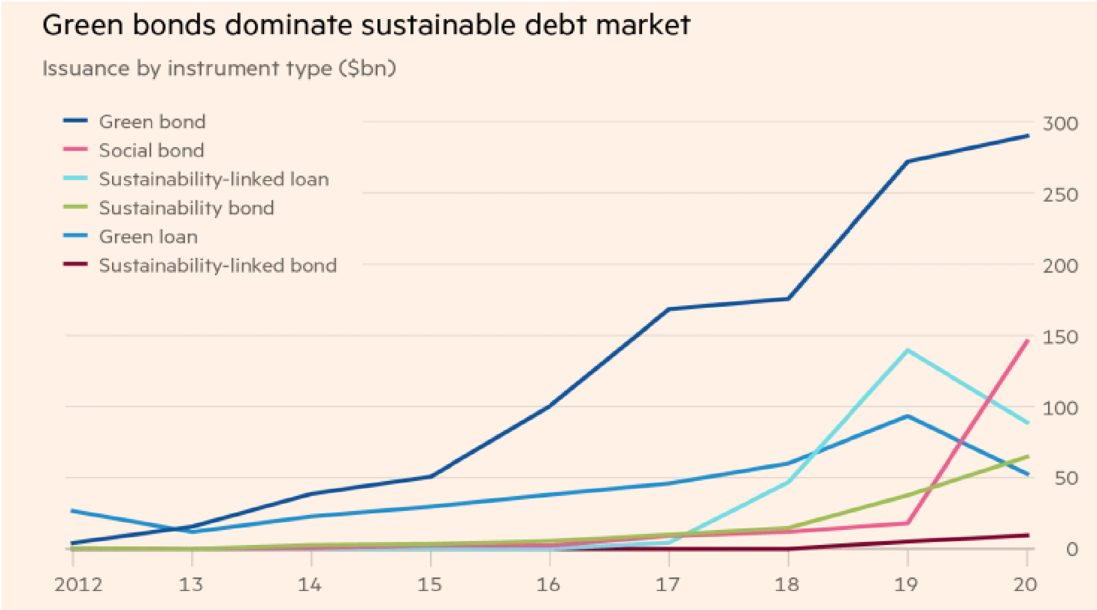
The use of RES technology creates a new sector of the economy. The green economy addresses all economic activity related to the reduction of fossil fuels, pollution, and greenhouse gas emissions. Further, it seeks to increase energy efficiency, recycling of materials, and use renewable energy sources. The drivers behind the green economy and technological achievements in the field of RES relate to (Lorek and Spangenberg, 2014):

1. the protection and sustainability of the environment,
2. economic growth and the creation of new jobs,
3. national security, and
4. the moral obligation of man towards future generations

Al-Darraji and Bakir (2020) investigate the impact of renewable energy on economic growth using a panel of 18 countries. The investigation period is from 2008 to 2015. The authors employ econometric analysis using variables such as renewable energy, labour, capital, and trade openness to assess their impact on real GDP per capita. Their findings suggest that renewable energy sources have a positive yet highly inelastic impact on GDP, which shows that investing in RES will decrease dependence on conventional energy sources. Evidence from 25 European countries investigates the relationship between energy consumption from RES and economic growth reflected on GDP per capita between 2007-2016. The findings confirm a strong correlation between GDP, RES and Non-RES energy consumption, gross fixed capital formation, and labour force. Also, there is a strong correlation between RES consumption and economic growth of countries with higher GDP (Ntanos et al., 2018). A study from Lithuania explores the impact of RES on the economy and finds that a long-term strategy for RES should be implemented and consider all stakeholders, including small investors and corporate players. In doing so, the economy will achieve efficient decentralized energy production based on RES expansion and higher security of the energy sector (Valodka and Valodkienė, 2015).

The 2018 Report of The Global Commission on the Economy and Climate finds that shifting to the mandatory disclosure of climate-related financial risks is an inherent element of a broader policy package. New policies aim to accelerate investment in sustainable infrastructure through the implementation of clear national and sub-national strategies. Also, innovation and advanced supply chain transparency should guarantee that the benefits of the energy transition will equally benefit all people (New Climate Economy, 2018). Further, according to the latest estimates of banks and financial rating agencies, in 2021 green bond market will take off. Green bonds have emerged over the past 8 years as a secondary, but emerging, financial tool due to the growing investor and bank interest in RES and sustainable development projects (Ehlers et al., 2020). Following the 2015 Paris Agreement on climate change mitigation, adaptation, and finance, the green bond market keeps growing globally (Figure 6-1).

Figure 6-1 Green bonds dominate sustainable debt market (2012-2020)



Source: Nauman (2021)

Swedish bank SEB estimates that, in 2021, green bonds to be issued will be close to $500 billion, almost double the total amount of capital raised in 2020. Estimates by HSBC predict that the total funds attracting green bonds will be between $310 and $360 billion. If these estimates prove valid, the consolidation of the market internationally could be realized on a large scale (Nauman, 2021).

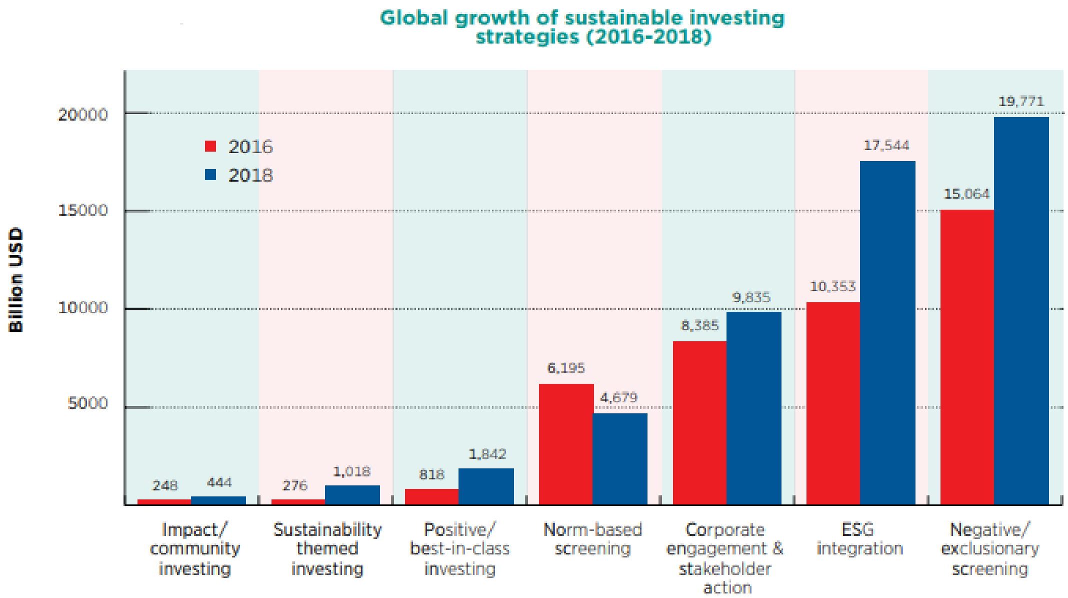
The great interest shown by investment banks and commercial banks in green bonds is partly due to intra-bank competition. Green bonds offer a fertile field of competition in terms of services and guaranteed returns. Further, green bonds offer a prestigious and environmentally sound recognition to both the issuer and the company that invests (United Nations, 2019). The positive estimates for the rapid growth of the green bond market in 2021 are based also on the European

Commission's decision to borrow €750 billion from international markets to finance the Recovery Fund. From this amount, €225 billion correspond to green bonds (European Commission, 2021d). Secondly, the return of the US in 2021 to the International Treaty of Paris is expected to have a positive impact on the promotion of RES projects and energy efficiency applications.

In 2015, Bank of England governor Mark Carney stressed that the stranded assets, namely coal, gas, and oil, amounted to a 20 trillion dollar "carbon bubble" that exceeded the housing bubble of 2008. The stranded asset debate shows that both the governments and key players in the oil and gas industry make decisions towards the low carbon transition. Global oil and gas companies face decarbonization pressures from regulators but must also guarantee investor returns. At the same time, by addressing these pressures, they are also displaying risk management effectiveness. Further, the capital markets should focus on "Paris-compliant" investments to comply with Paris Agreement (Johnston, 2020).

As seen in Figure 6-2, global growth of sustainable investing between 2016 and 2018 is driven by corporate engagement and stakeholder action (+17.3%), ESG integration (+69.5%), and negative exclusionary screening (+31.2%).

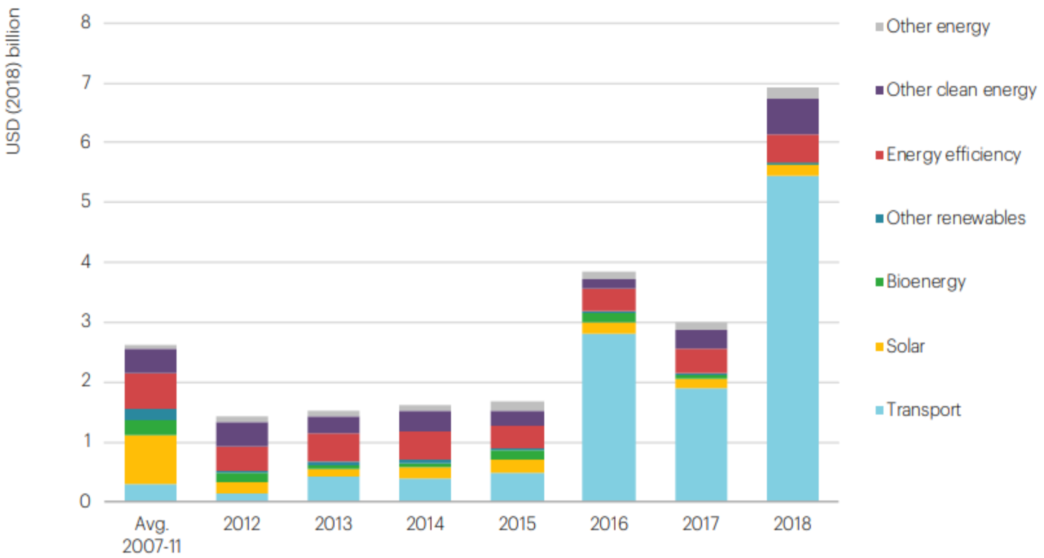
Figure 6-2 Global growth of sustainable investing



Source: Johnston (2020)

Venture capital investment in energy companies through seeding, Serie A and Serie B reached $6.9 billion. Although the total investment amount is lower than the amount invested in research & development projects, the growth trend of venture capital deals in clean energy technologies is evident. While solar energy occupied a substantial share of transactions before 2012, 2018 growth has been driven almost entirely by clean transportation investment. Most of the transport deals are in electric vehicle (EV) technology and services (Figure 6-3).

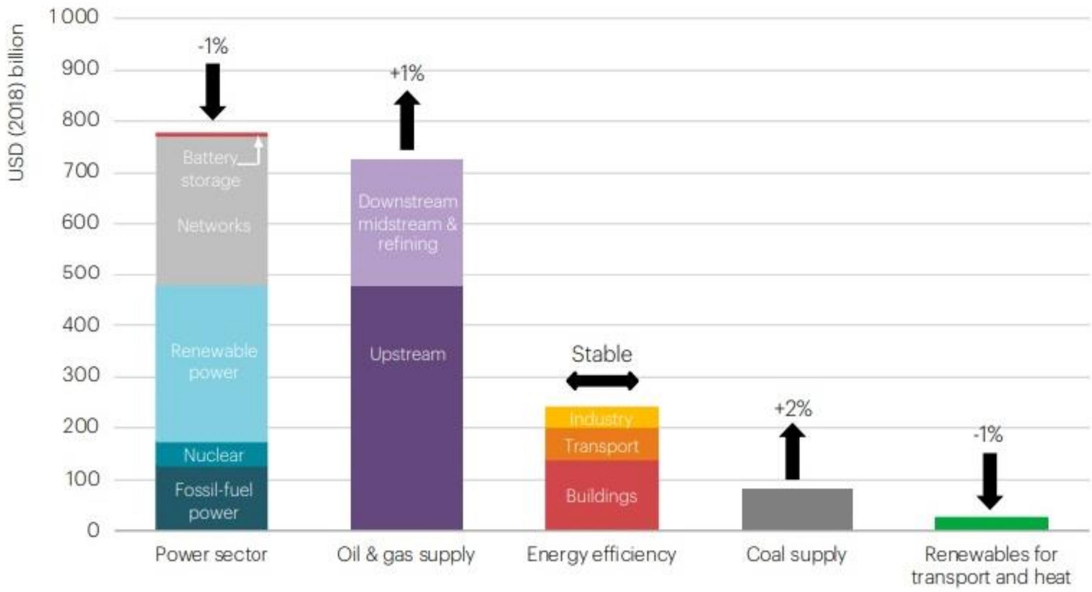
Figure 6-3 Global venture capital investment in energy technology companies



Source: IEA (2019)

Figure 6-4 shows global energy investment in 2018 by sector and y-o-y performance compared to 2017. Investments in the power sector, including fossil-fuel power, nuclear power, renewable power, networks, and battery storage, declined by 1%. Investments in oil and gas supply (upstream, downstream, midstream & refining) increased by 1%. Investments in energy efficiency, including buildings, transport, and industry remained stable. Finally, investments in coal supply increased by 2%, and in renewables for transport and heat decreased by 1%.

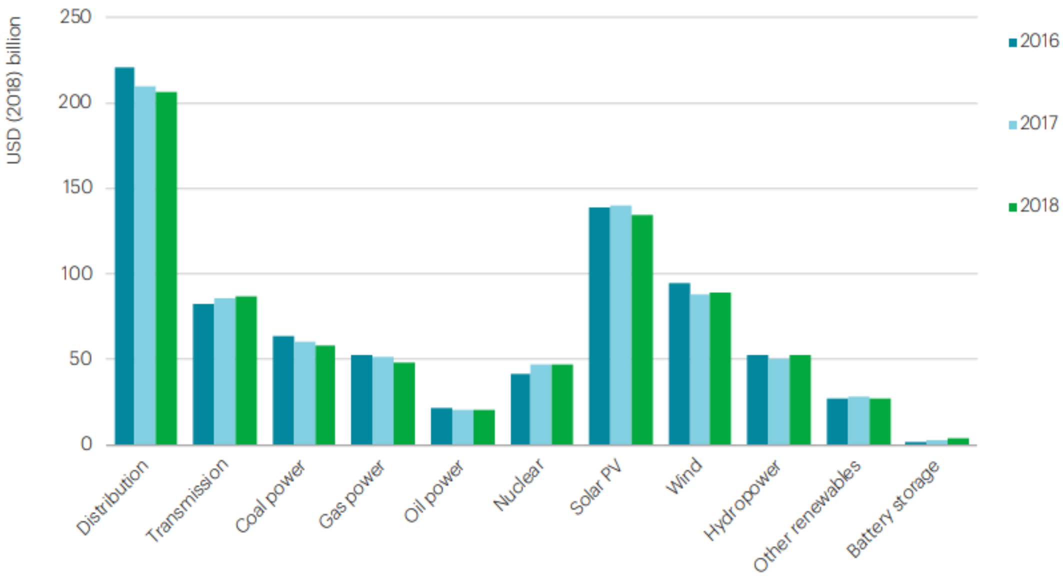
Figure 6-4 Global energy investment by sector (2017-2018)



Source: IEA (2019)

On the other hand, global electricity investment declined by 1% in 2018 due to lower capital spending on coal and gas power, solar photovoltaic, and distribution (Figure 6-5).

Figure 6-5 Global investment in the power sector by technology



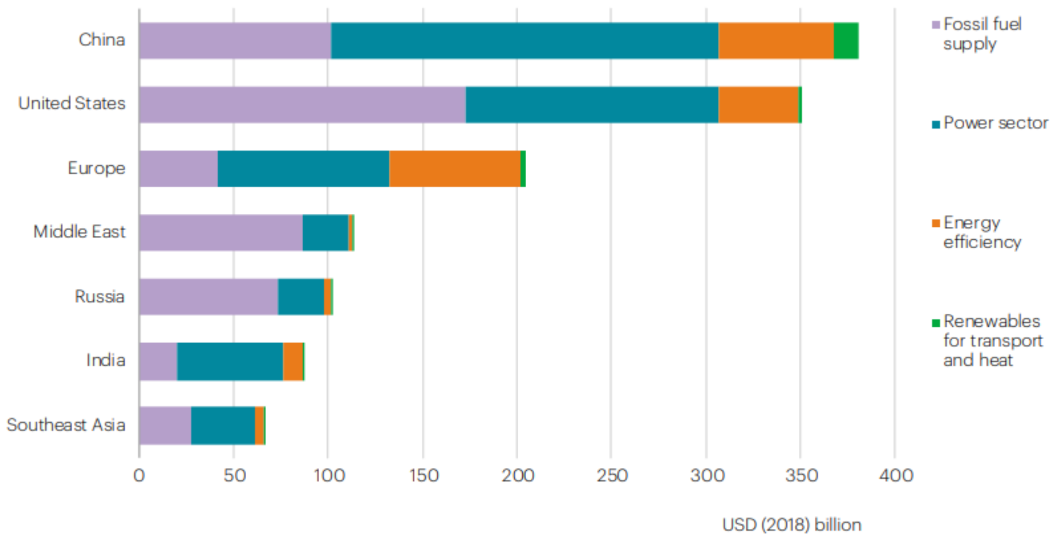
Source: IEA (2019)

The United States drive most of the growth in energy supply investment since 2010, with increases in oil and gas and the power sector. Oil and gas spending has strongly grown y-o-y. Further, investment in RES power and gas power remained relatively stable, yet high as opposed to investment in energy efficiency that declined since 2017 (IEA, 2019).

China remained the leader in energy investment in 2018, but its lead lessened. While spending is mostly driven by low-carbon electricity supply and networks, total investment declined -7% since 2015 due to lower spending on new coal-fired plants (-60%), offsetting investment in RES and nuclear power. On the other hand, energy efficiency spending grew +6% between 2015 and 2018 (IEA, 2019).

Energy investment has risen most rapidly in India (+12%). In 2018, renewable spending continued to outstrip fossil fuel power spending, supported by tendering for solar PV and coal supply (Figure 6-6).

Figure 6-6 Energy investment by sector in selected markets in 2018

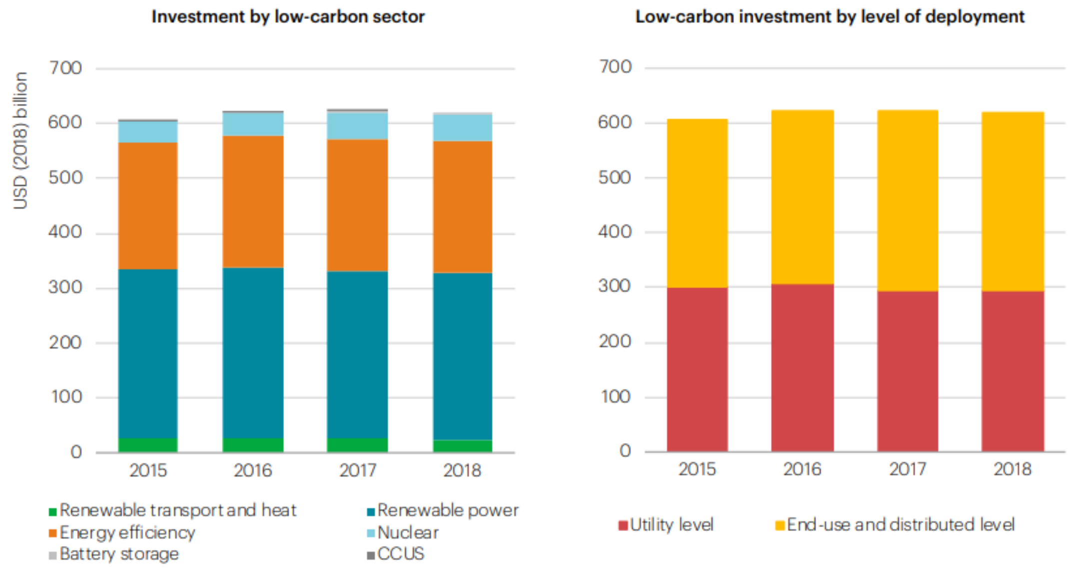


Source: IEA (2019)

Investment in the supply and demand of low-carbon energy remained fairly stable at $620 billion in 2018. Spending growth has stagnated since 2016 and the share of low carbon in total energy investment was near 35%. Investment in electricity grids to enable clean energy transitions has declined fairly since 2016 (IEA, 2019).

Low-carbon spending in 2018 demonstrated stable investment activity in energy efficiency and nuclear power. Battery storage investments grew by almost 50% but represented just over 1% of total grid spending. Spending on RES for transport and heat declined slightly, with more biofuels investment offset by lower spending on solar heating installations (Figure 6-7).

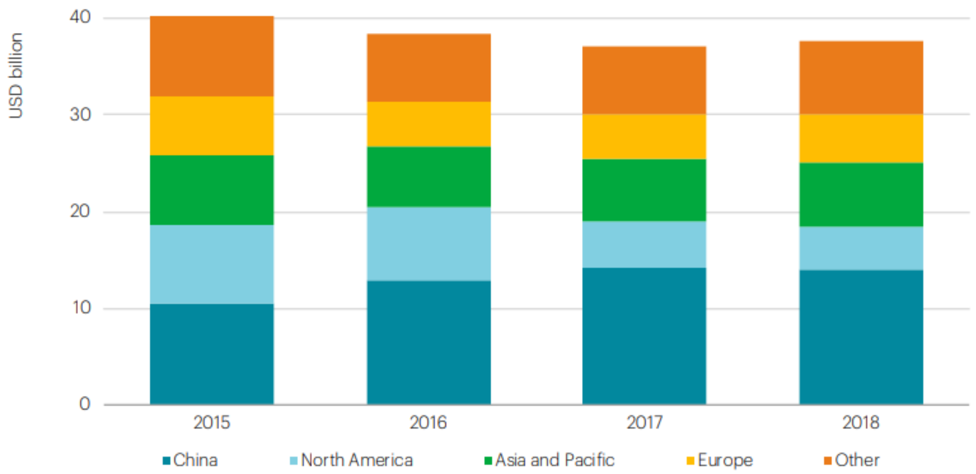
Figure 6-7 Global investment in low-carbon energy by sector and level of deployment



Source: IEA (2019)

In 2018, $240 billion were invested in energy efficiency across the buildings, transport, and industry sectors, remaining at the 2017 levels because of lower spending on energy-efficient buildings, -2% to USD 139 billion. The buildings sector occupies the largest share of energy efficiency spending. According to IEA (2019), energy efficiency investments should increase significantly in the short term to meet global sustainability objectives and restrict the implementation of energy supply measures. Investment in industrial energy efficiency did not exceed %40 billion in 2018 and has been relatively constant since 2015. However, the market composition has changed. China represented 37% in 2018, up from 25% in 2015. North America fell from 17% in 2015 to below 10% in 2018, reflecting the ongoing modernisation of the Chinese industrial sector and efforts to improve energy efficiency. At just over 45%, heavy industry share of global industrial energy efficiency investment is lower than in 2015, nearly 50%, reflecting the ongoing slowdown in the development of energy-intensive industrial facilities in China and the structural changes in major economies. India is an emerging source of industrial energy efficiency investment in the Asia and Pacific region, to nearly +5% due to modernisation of industrial facilities and strong mandatory government policy (Figure 6-8).

Figure 6-8 Investment in industrial energy efficiency by region



Source: IEA (2019)

In Greece, PPC announced the successful pricing of its debut international offering of € 650 million sustainability-linked senior notes due 2026 - coupon price 3.875%, issue price 100%. The notes will be issued in compliance with Law 4548/2018[20] and Law 3156/2003[21] and will be governed by New York legislation. The proceeds from the Offering will be used towards the repayment of PPC's existing debt, general corporate expenses, and Offering-related costs. The company has the sustainability-linked senior notes listed on the Euronext Dublin and traded on the Global Exchange Market or any appropriate trading venue in the European Union. The Joint Global Coordinators and Physical Bookrunners of the Offering are HSBC Continental Europe S.A., also acting as Sustainability-Linked Bond Structuring Advisor and Goldman Sachs Bank Europe SE. Citigroup

[20] https://www.cpalaw.gr/media/1109/cpa_newsflash_%CE%BD45482018_18-6-2018-en.pdf
[21] https://ec.europa.eu/info/sites/default/files/file_import/greece-base_en_0.pdf

Global Markets Europe AG is a Joint Global Coordinator and Joint Bookrunner. Other Joint Bookrunners are Alpha Bank, Ambrosia Capital, AXIA Ventures Group, Credit Suisse Securities, Eurobank, J.P. Morgan, National Bank of Greece, Piraeus Bank, and Sociedad de Valores (HAEE, 2021).

6.3 Power Purchase Agreements (PPAs)

A Power Purchase Agreement (PPA) is a long-term electricity supply bilateral agreement between a power producer and an electricity consumer or trader that specifies all the commercial terms of the sale of energy between the two parties. Such terms include the amount of electricity to be supplied, negotiated prices, schedule of delivery of energy, accounting, penalties for non-compliance, and termination of the agreement.

Electricity can be supplied physically or virtually. PPAs can be used to reduce market risks and prices, which is why they are regularly selected by large electricity generators and consumers to diminish investment costs and operating costs, respectively. PPAs provide the buyer with predictable long-term prices and the ability to act sustainably while enabling the generator to secure a stable revenue stream and increase the bankability of the renewable energy project.

There are different structures of PPAs based on the risk profile of the parties involved in the agreement. The risk-price profile of different PPA structure include:

- Baseload: it refers to volume delivery obligation and hourly profile obligation
- Fixed Annual / Quarterly Volume: it refers to volume delivery obligation and has no delivery profile obligation.
- As Produced: it has no volume delivery obligation and no delivery profile obligation.

Alternatively, there is the possibility to embed financial instruments and protect investors from falling prices while capitalising on the upside potential. The main types of Power Purchase Agreements are Physical PPAs and Virtual PPAs.

In a Physical PPA, an organization (buyer) enters a long-term contract with a third-party generator (seller) who agrees to build, maintain, and operate a renewable energy system either on the customer's property (on-site) or off-site. Regardless of whether the system is on-site or off-site, the buyer receives the physical delivery of electricity through the grid and agrees to purchase the power at a set price over an agreed-upon term. The generator assumes the risks associated with owning and operating the system. Also, a sleeved PPA is a Physical off-site PPA in which an energy service provider acts as an intermediary between the generator and the buyer. The service provider is responsible for balancing group management; aggregating several electricity generators to its portfolio; supplying residual quantities of electricity; selling surplus quantities; preparing forecasts, promoting green certificates; or assuming risks, such as balancing energy costs or default/insolvency risks (EPA, 2021).

A Virtual Power Purchase (VPPA) or Financial/ Synthetic PPA is a long-term contract with a maturity of 10 to 20 years between a developer of a renewable energy project and an energy buyer. As in a direct PPA, the buyer assures that the developer receives a fixed price for their energy. Yet, a VPPA includes a “contract for differences” settlement, which compares the fixed price and the floating market price. When the market price is higher than the fixed VPPA price, the developer pays the positive difference to the buyer. If the market price falls below the fixed VPPA price, the buyer pays the developer the difference. Hence, the contract for difference can make an essential difference in markets, especially when the prices are volatile (Imolauer, 2020).

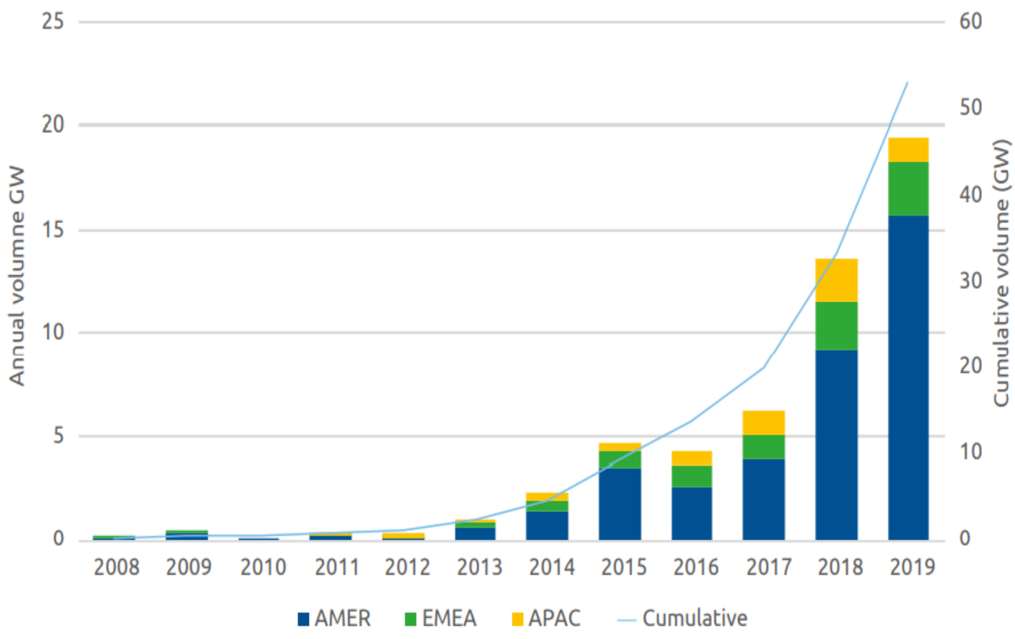
According to the World Bank (2021), PPAs are used for power projects when:

- The forecasted revenues would otherwise be doubtful. PPAs act as a guarantee to quantities purchased and the price paid to ensure the viability of the project.
- Cheaper or subsidized local or global companies become competitive by producing cheaper power.
- There are major customers willing to take the bulk of the product. For example, a government utility may purchase the power generated by a power plant and wants a breakdown of how much it pays for the power

and ensure that it has the first call on that power. The project company seeks a revenue guarantee, and the buyer seeks the security of supply.

Corporate PPAs are on an upside trend since 2014. The European corporate renewable PPA market has grown to a cumulative capacity of more than 8GW for offsite projects. In 2018, there were PPAs of 1.3 GW of commercial renewables and 2.1 of industrial on-site renewables while in 2019, more than 2.5 GW of offsite PPAs were contracted (Figure 6-9).

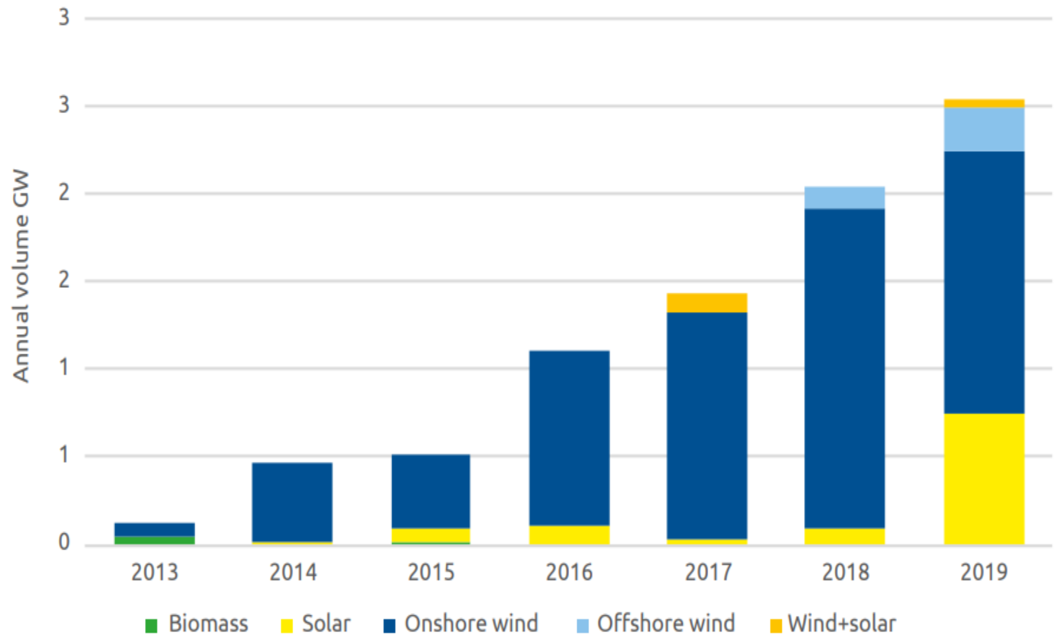
Figure 6-9 Global corporate offsite PPA volumes, by region



Source: Wind Europe (2020)

Roughly 85% of corporate PPAs in Europe have been contracted for wind energy mainly because of the activity that has taken place in Norway, Sweden, and the UK, i.e., countries with a high wind resource. Furthermore, wind projects are normally larger than solar photovoltaic projects, enabling corporate purchasers to procure larger volumes of power in single transactions. In 2019, solar photovoltaic PPAs accounted for nearly 30% of the contracted capacity (Figure 6-10).

Figure 6-10 European corporate offsite PPA volumes, by technology



Source: Wind Europe (2020)

6.3.1 Advantages and Disadvantages of PPAs

The advantages of PPAs include electricity cost savings with no up-front capital costs and long-term price security and cost predictability. PPAs facilitate the development of new renewable electricity projects and offer buyers the ability to purchase a large volume of electricity through a single transaction. In doing so, they reduce the risks associated with energy sales and purchases and provide financing opportunities. Buyers engage directly with a RES project and negotiate all commercial terms of the contract without assuming any risk. Sellers that use PPAs that address the regional characteristics of a physical supply of electricity create the opportunity to make their product more sustainable (Imolauer, 2020).

On the other hand, PPAs are complex contracts and require a great deal of time and negotiation before the conclusion. Long-term PPAs carry inherent risks that corporates are typically not used to deal with. In addition, electricity production, especially from wind and photovoltaics, can fluctuate. If the quantities of electricity agreed upon are not available at the time of delivery, the plant operator must provide financial or physical compensation, or outsource to a third party.

Finally, customers may not have the same economic benefit of outright ownership (Imolauer, 2020).

6.3.2 Priorities of PPA use

The main priority for the next period is the update, simplification, and operational efficiency of the licensing and spatial framework for RES. In this context, existing technologies will evolve, and new tools will enable the optimal provision of relevant information to all stakeholders. The PPAs aim to (NPEC, 2019):

- implement the production framework from RES,
- achieve compliance with specific timetables regarding the evaluation and issuance of authorisations acts, and
- codify relevant legislation to ensure uniform and accurate information to the licensing authorities and interested parties.

In addition to updating the licensing framework, PPAs will consider the new requirements and operational possibilities of the projects and establish central contact points to facilitate licensing. In doing, so, it is expected that the development and implementation of the required units RES to achieve the national target will be successful. Furthermore, regarding distributed production of RES systems, the schemes of self-production, energy netting, and virtual energy offset, PPAs will carry specific technical characteristics, criteria, and administrative requirements. The development of a specific institutional framework for the promotion of energy communities is currently under implementation in Greece and considered an essential tool for strengthening the role of local communities and consumers. Therefore, the operation of these schemes will be supported by the use of licensing and operational incentives, including limited participation and representation in the electricity market. PPAs are expected to be important in energy communities and energy netting schemes, maximizing the benefits to the local economy (NPEC, 2019).

6.4 The next day for energy in Greece

The electricity market in Greece is changing following the agreement between the Greek government and the European Commission on the compliance measures related to the anti-trust case, i.e., the case of condemning Greece for the dominant position of PPC in the lignite market. The case, which has a time depth of more than 14 years, is settled with the adoption of a regulatory mechanism for the distribution of electricity. In essence, PPC is required to distribute quantities of electricity to independent suppliers through power purchase agreements (PPAs).

The main points of the agreement are the following:

- Power purchase agreements will have a quarterly or annual duration.
- PPAs will be available from the PPC to the market for 3 years.
- PPAs will amount to 50% of last year's lignite production. Given that PPC lignite production is declining, PPAs for 2021 will amount to 3TWh and in 2022 between 2 to 3TWh.
- The price of PPAs will be determined in relation to the price of the pre-market purchase of the energy exchange with a specific discount.
- All holders of electricity supply licenses will have the right to conclude PPAs.
- The products will be made available through an invitation of expression of interest and not through auction procedures.
- If the demand is greater than the quantities available, the suppliers will be satisfied proportionally according to the quantities requested.

The first reaction from PPC was positive, and business circles point out that the quantities of energy made available to third parties are small. Also, the fact that the selling price of PPAs will depend on the market price will protect PPC from leaks. Further, the agreement acts as a catalyst for the normalization of the operation of the Target Model, paving the way for the conclusion of bilateral sales contracts between producers and suppliers. Suppliers will be able to buy quantities of energy at constant prices even if there is market volatility that significantly increases risks. Under this perspective, the agreement could normalise the supply market, which had been shaken due to sharp fluctuations in electricity costs (Floudopoulos, 2021).

The ongoing energy bill submitted to the Parliament in June 2021 brings drastic changes in the licensing of the RES stations. Investors that enter bilateral contracts (PPAs) will have priority in licensing over those who seek to secure tariffs through RA tenders. This is a critical incentive, considering that 3.5 GW in RES is expected to go through tenders by 2024 with the participation of both new and established players. In essence, the new energy bill offers incentives to investors to stop aiming at earning stable prices, as those who choose the stock markets through green bilateral contracts will face a more favourable environment.

On the other hand, projects with fixed tariffs through tenders facilitate bank financing. Investors who conclude a PPA contract should be able to present a strong proposal to be financed as opposed to investors who are not that familiar with PPAs. In the long-term, conscious players will be able to use the faster licensing of their project as another tool for bank financing.

The new energy licensing framework seeks to operate in a digital environment, with faster-automated procedures. The government's goal is to reduce the duration of the licensing process to 2 years to the EU corresponding levels (Fintikakis, 2021).

In the Athens Energy dialogues that took place on 17 and 18 February 2021, five basic principles drive the vision for the next day for energy in Greece. These are:

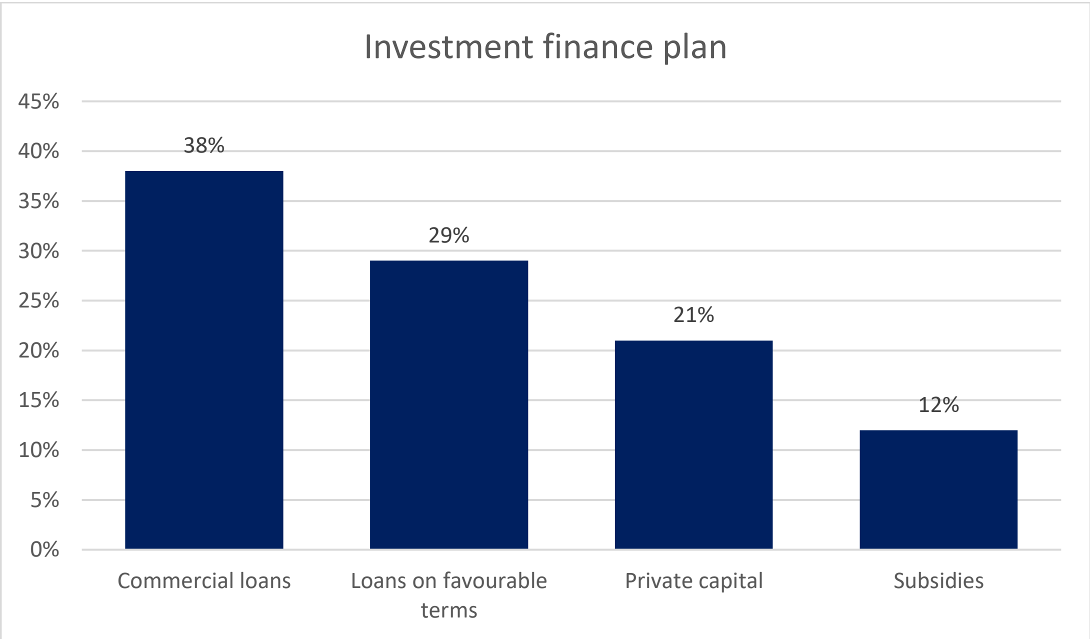
- Emphasising labour intensive sectors for the creation of employment opportunities in the local communities.
- Capitalising on the inherent advantages of affected regions.
- Ensuring quick transition by focusing on quick wins.
- Promoting social and environmental sustainability with a focus on sustainable development.
- Integrating new technologies and promoting a spirit of innovation to all activities.

According to Dr. Prontzas, there are two types of motives for the businesses and one type of motives for the employees.

- The motives to attract a new production process include providing a grant for new investment, tax exemptions, tax reliefs, subsidies of insurance contributions, fee exemption, loans on favourable terms, and guarantees.
- The motives for going concern include grants for the reform and modernization of the productive operations, salary cost subsidy, loan obligation subsidy, equity participation, and loans on favourable terms.
- The motives for employees include income tax deduction, mortgage subsidy, and reinforcement of training programs and benefits.

Financing of these motives and investments will be through global financing, incusing JTF, ESF, ESF+, Rights, Equality and Citizenship Programme (REC) as well as through national funding agencies. As seen in Figure 6-11, 38% of financing will come from commercial loans, 29% from loans on favourable terms, 21% form private capital, and 12% from subsidies.

Figure 6-11 Investment finance plan



Source: Prontzas (2021)

These developments will further boost investments in the country. The de-lignification plan will create more jobs, but energy investments are expected to create more job opportunities. During the construction phase, 8,000 new jobs will be created and during the operation phase 8,100 new jobs will be created. Of these, 1,710 are directly affected and 4,959 are indirectly affected by energy investments while there is a surplus of 1,431 new positions. Finally, the de-lignification plan is driven by the following factors (Prontzas, 2021):

- Implementation of a governance model for Fair Development Plan.
- Fair Development Plan management and monitoring.
- Land management and commissioning studies.
- Overall coordination of project implementation.
- Inclusion of investment proposals

Typical examples of the increased energy investments in Greece are the Volkswagen project in Astypalea (Bellos, 2020), the construction of the first non-domestic factory of the German electric car company Next. e.Go Mobile in Greece (Spasić, 2020), and Microsoft's investment to create three Cloud-Computing centres in greater Athens providing up to $1 billion investment to the Greek economy (ekathimerini, 2020). The Greek government did not deviate from its most important goal, to attract new investments that can improve the country’s competitiveness.

6.5 Chapter conclusions

The new production units together with the existing ones in combination with the undoubted abilities, the accumulated experience, and the know-how of the energy operators in Greece can ensure the country’s smooth shift to the energy transition. Continuing production and delivery of smart meters globally will help many countries to achieve their ambitious goals of technology and sustainable development but also to upgrade their energy infrastructure.

7. Conclusions

7.1 General conclusions

The energy sector has undoubtedly been significantly affected by the coronavirus pandemic, which has reduced global demand by at least 4%, especially in oil, gas, and coal. The key challenges for the energy sector as it stands today are summarized in energy security, in the stability of energy prices products, and in tackling climate change. Additional challenges of the power generation sector are, on the one hand, interconnections, and the reliability of the electricity grid for the transmission of electricity to final consumers, on the other hand, the ensuring storage capabilities.

Nationwide, there is a growing demand for energy in the last 20 years. The Greek energy system uses a large percentage of conventional fuels for electricity and energy production, with lignite being a strategic choice, as it is the main domestic fuel. In this context, the energy transition of Greece to renewable energy sources is a challenge that requires stronger infrastructure and modernised networks. Over the next decade, IPTO's €5 billion investment plan includes the penetration of 17 GW of new renewable energy sources and interconnection projects, including the island interconnections. Especially, the interconnection of Crete is a record project due to the depth and length of the cable. At the same time, the interconnection between Crete and Attica is progressing, and the intensive interconnection program of the Cyclades continues. The plans through 2030 also include the interconnection of all the islands as well as with other countries (Egypt, Libya, etc.) and offshore wind farms.

Since November 2020, Greece participates in the Target Model - the single wholesale market model applied in all EU countries. Greece is thus complying with a fundamental obligation towards the EU for the creation of a single European electricity market to remove trade restrictions and allow the connection between national markets. The promotion of competition, the greater convergence of prices in the Greek market with neighbouring ones, the formation of a transparent framework for market costs, the highest quality operation of the electricity system, and the efficient use of energy resources will ultimately benefit the Greek economy and the Greek consumers through extended access to cheaper energy sources and PPAs.

RES is the only way for the energy transition to a clean planet. This is because renewable energy sources are abundant and inexhaustible, and scattered on the planet, thereby contributing to energy independence, geopolitical balance, and peace. Furthermore, renewable energy sources do not pollute but instead replace fossil fuels that pollute during extraction or pumping, transport, storage, and incineration. Also, they do not emit greenhouse gases, but instead replace sources that emit greenhouse gases, thereby protecting health. Finally, RES are compatible with other development goals such as tourism and land value, create employment and regional development, and contribute to the diffusion of development and social cohesion.

The penetration of double-digit GWs from renewable energy sources will take place shortly if Greece continues to invest in the structural transformation of RES. Greece has set a goal to reduce CO2 emissions from electricity generation by 69.6% and improve energy efficiency by 38%. The share of RES in Gross Final Energy Consumption is expected at more than 35% and the share of RES in the gross final electricity consumption is expected between 61-64% through 2030. In this context, HEDNO will be a catalyst in the transition of the Greek energy market to a market of active consumers and environmentally friendly technologies. Currently, HEDNO works for the digitization of systems with smart meters, the modernization of networks, and the upgrade of services.

By 2023, Greece is expected to have completed major advancements in energy transition despite its macroeconomic challenges such as lower public revenues, higher government expenditures, debt accumulation, and the threat of increased non-performing loans due to the COVID-19 pandemic. At the same time, tackling climate change and the need to improve air quality in the Greek ports requires an urgent energy transformation. Ports must become energy hubs, where the production, storage and distribution of electricity will coexist. Europe is already shifting to greener ports, having placed tackling climate change a top priority over the coming years. Greece has a strong maritime tradition and many ports. This is a competitive advantage and provides a motive to act in a coordinated way to reduce their environmental footprint. As a popular tourist destination, Greece accepts different types of ships, including cruise ships with high energy needs. In this direction, zeroing ship pollutants by providing energy from the land to avoid the use of their engines that burn oil is an especially important step.

Concluding, the potential for growth in the energy sector in Greece and its contribution to economic growth can turn energy into one of the most important sectors for the economic prospects of Greece. More than its direct contribution to production and employment, the energy sector potential relates to energy costs and the security of energy supply for improving the competitiveness of the Greek economy. Also, it has the potential to attract investments for the development of domestic energy resources and the modernization of energy infrastructure.

7.2 Suggestions for further research

Given the dynamic nature of energy investments, it would be interesting to investigate the impact and investment needs overview by performing an impact analysis of key national planning policies. Also, existing investment flows and assumptions of projected investments should be considered to assess the interaction and impact of energy policies and energy efficiency / savings. Finally, risk factors and challenges should also be taken into account.

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